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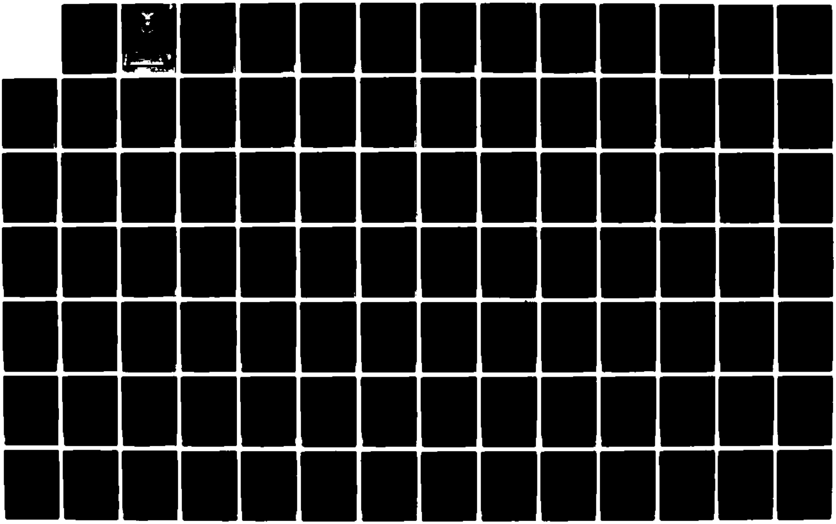

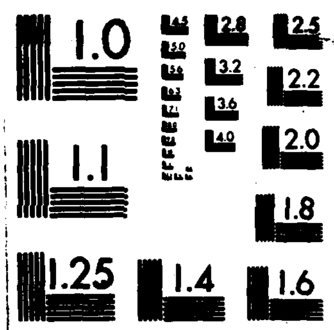

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A DYNA-METRIC ANALYSIS OF SUPPLY SUPPORT FOR MOBILE TACTICAL RADAR UNITS IN EUROPE

THESIS

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Captain, USAF

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AFIT/GLM/LSM/84S-43

A DYNA-METRIC ANALYSIS OF SUPPLY SUPPORT FOR MOBILE TACTICAL RADAR UNITS IN EUROPE

THESIS

Presented to the Faculty of the School of Systems and Logistics
of the Air Force Institute of Technology
Air University
In Partial Fulfillment of the
Requirements for the Degree of
Master of Science in Logistics Management

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September 1984

Approved for public release; distribution unlimited

Preface

In this thesis, we presented a quantitative and qualitative analysis of supply support for mobile radar units in Germany. The ideas, background, and scenarios were drawn from our combined 8 years experience in the U.S. Air Force Europe (USAFE) TACS, both at the unit and 601 Tactical Control Wing (TCW) staff levels. We felt the wartime support of the units would not meet their actual needs, and wanted to make a clear statement on how to best meet their needs with current resources available to the 601 Tactical Control Wing (TCW). We essentially chose two methodologies to analyze and present our views. This thesis is written and organized to separate the methodologies where necessary, but present a single background (Chapter 2) and draw common conclusions (Chapter 6).

The qualitative analysis of the units was approached from a systems analysis standpoint (Chapter 3). The principle elements in the system were the units, base supply, distribution, 601 TCW command post, HQ USAFE, and Air Force Logistics Command (AFLC). The relationships between all elements were explained, and supply support problems were highlighted while discussing the wartime relationships between the elements. Six resupply system alternatives, each of which could improve some aspect of the current system, were then presented and analyzed. This analysis ended by proposing a method to "fix or minimize" the wartime problems. This "best" method appeared to be a combination of prepositioned stocks and improved intra-theater transportation.

Based on this conclusion, a quantitative comparison of the current support structure and the proposed "best" method to improve the structure through prepositioning was conducted using spare parts data provided by the 601 TCW (Chapter 4). For this methodology, we chose to use the Dyna-METRIC model. We first verified the model could be used for communications-electronic equipment, then used the data provided by the 601 TCW to model the two support scenarios. This represented the first time the Dyna-METRIC model was used for communications-electronic equipment, and applied to realistic scenarios using actual data from the field.

Chapter 5 shows the results of our Dyna-METRIC runs to model the two TACS resupply system configurations. Chapter 6 presents our conclusions. We felt the model was flexible and adaptable enough to adequately apply to communications-electronic systems. The results were realistic and may be useful to logistic planners in preparing wartime support plans. We strongly recommend AFLC and Air Force Communication Command (AFCC) continue research into the methods and techniques we used to apply the Dyna-METRIC model to mobile systems, and then fully implement the model to analyze all communications-electronic systems used in the Air Force.

The conclusions presented in Chapter 6 reflect how successfully we met our objectives. We feel the objectives were adequately met, and by doing so we have clearly demonstrated: 1) the utility and flexibility of the Dyna-METRIC model, and 2) that the supportability and operational capability of the TACS can be improved through the use of a prepositioning concept.

We wish to thank our wives and families for their support, patience, and cooperation during the last year. Our thanks also goes out to the Management Science Section, HQ AFLC/XRSA for their help and support in running the Dyna-METRIC model. We particularly wish to thank Mr. Mike Niklas for his help in validating options 10 and 16, providing input formats, and his listening ear when we ran up against problems. We also want to thank the Commander and Staff of the 601 TCW, Sembach AB, Germany. In particular, we wish to recognize Lieutenant Colonel George W. Pickard and his staff in 601 TCW/TLM for the data and direction they provided. Finally, we wish to express our appreciation to our thesis advisor, Captain Mike Budde, for his help and support throughout this project.

Richard D. Mabe

Robert E. Ormston

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Abstract

This investigation determined that there is an improved way to structure the resupply system used to support the USAFE TACS. After analyzing the resupply system, and examining six alternative resupply systems qualitatively, the "best" method of resupply was postulated to be one using several forward supply points (prepositioned stocks) with dedicated transportation assets to support these points.

This "best" method was then modeled using the Dyna-METRIC model developed by the Rand Corporation. This model was originally developed for application to aircraft systems. This thesis represents the first time the model was adapted to accommodate mobile communications-electronics equipment. The model compared the proposed "best" method of resupply against the resupply system currently in use in USAFE. The model quantitatively substantiated the proposed "best" system could improve resupply support for the USAFE TACS.

Two significant findings were derived from this study. First, the Dyna-METRIC model is flexible enough to accommodate systems other than fighter aircraft. Secondly, intra-theater prepositioning is a viable concept which can enhance supply support for the USAFE TACS.

A DYNA-METRIC ANALYSIS OF SUPPLY SUPPORT FOR MOBILE TACTICAL RADAR UNITS IN EUROPE

I. Introduction

Background

"To-fly-and-fight" usually comes to mind, when thinking of the Air Force mission, bringing with it images of sleek F-15s gracefully outmaneuvering Soviet MIGs, and making the skies safe for democracy. It is hard to imagine this romantic air war being waged by mud covered airmen with their feet firmly planted on the ground, working hard to win the war in the skies. These little known warriors man and operate a small number of mobile radar systems, and provide much needed "eyes" to those engaged in the aerial combat above. Though ground based, they are critical to the air war because they can see the enemy in its own territory long before it approaches the borders of the free countries of Central Europe. The radar units of the U.S. Air Forces Europe (USAFE) filling this mission are part of the USAFE Tactical Air Control System (TACS).

USAFE operates 15 of these mobile radar units in Germany, and although they are not a major weapons system, they do play a key role as a back-up to fixed radar sites of the NATO Air Defense Ground Environment (ADGE). North American Treaty Organization (NATO) warplans for air defense are written under a general assumption that mobile radars will survive enemy air attacks early in a war, while the fixed radar sites may be damaged beyond usefulness. To survive, the mobile radar units must frequently redeploy from one location to another. These frequent moves create supply problems not experienced by fixed units.

Base supply at Sembach Air Base (SAB), Germany directly supports 9 TACS units in the Southern part of Germany with peacetime and wartime supply services. The remaining 6 units are supported through a base supply satellite account at Hessisch-Oldendorf Air Station (HOAS), Germany, which provides limited spares and War Reserve Material (WRM) support. Units must still depend on SAB for the remainder of the items the satellite does not supply. In peacetime, order and ship times (OST) for supplies from SAB to the units are relatively stable. Units have reliable communications to order supplies, and base supply can make deliveries via highway, or by air using CH-53 helicopters which are based at SAB. During wartime these OST values may vary greatly due to four conditions not found during peacetime:

(1) Ground travel restrictions will be strictly enforced by NATO and U.S. commanders. Major roadways will not be open for general use, and combat vehicles will have priority over support vehicles. Backroads that are open will be filled with civilians fleeing the combat zone and military traffic of a lower priority.

(2) Air travel in combat areas will be severely restricted and controlled to avoid destroying friendly aircraft. Combat aircraft will have priority over support aircraft.

(3) Deployed radars will only have limited communications with base supply. Requests for supplies will be relayed via HF radio or tactical telephone, to the 601 Tactical Control Wing (TCW) command post, who will inform base supply. Delivery drivers will then have to locate the TACS units to make deliveries; not an easy task during a war.

(4) NATO air defense commanders will direct TACS unit movements and subsequent operations, not USAFE agencies. USAFE agencies will only ensure that supply and maintenance support are provided. It is highly conceivable a unit will be directed to move before they receive supplies being delivered from SAB, and the delivery driver may have no idea of the unit's new location.

The broad variance in OST values between a unit and SAB will mean: (1) unit commanders may not know when replacement supplies will arrive, and (2) permanent pipelines to provide follow-on supply support, following War Reserve Spares Kits (WRSK) depletion, may not be established when needed. In this uncertain environment, units may become non-mission capable for lack of spare parts (NMCS) even after surviving an enemy attack. With mobile radars down for parts and static radars destroyed, NATO commanders will lack a radar picture of enemy air activity and will only be able to speculate on the nature of the threat they face.

Justification

Justification for this thesis is three fold. First, the TACS is an integral part of the NATO air defense system. It is one of the few major command and control systems that is expected to be survivable, and remain in operation after other fixed air defense systems are destroyed. Any actions taken that can enhance the maintainability and survivability of this system will help to improve the overall NATO air defense posture.

Secondly, a complete analysis of the current supply system for TACS units in Germany has never been conducted. Small scale, live exercises involving single units have revealed some support problems. Although desireable, a full scale live exercise of the entire TACS would be costly, and still may not fully simulate all the wartime variables that may effect the resupply system. Computer modeling provides a relatively inexpensive method to assess the entire resupply system, or parts of the system, without the cost and trouble associated with a live exercise.

Finally, in a war, it is imperative to have a resupply system that can sustain and maintain the operational capability of its users. The current resupply system, designed to maintain the operatioal readiness of the USAFE TACS, may not provide the level of responsiveness needed to ensure that mobile radar units will be operational when needed by NATO commanders.

Specific Problem

There is a need to know if there is a reasonable method of improving the resupply structure that supports the USAFE TACS. Under the current resupply structure, mobile TACS radar units are likely to experience unpredictable and unnecessary periods of downtime due to the inefficient method of being resupplied coming solely by Sembach AB.

Research Proposal

This thesis evaluates intra-theater prepositioning as a method to alleviate the problem of inefficient resupply support from a single point of distribution. Prepositioning spare parts and supplies at various site closer to unit wartime locations may increase the probability that support will be available for each unit when needed, thus increasing the overall mission readiness of the USAFE TACS.

Research Objectives

In order to substantiate the concept of prepositioning, this research effort set out to accomplish the following objectives:

(1) Conduct a system analysis of the USAFE TACS to describe the resupply system relationships, select a "best"

alternative resupply system to model, and substantiate this alternative as a viable concept through a modeling effort.

(2) Determine if the DYNA-METRIC model, designed for aircraft supply support, can be adapted to accommodate mobile communications-electronic (CE) equipment support.

(3) Use Dyna-METRIC to evaluate the current resupply system against the viable alternative resupply system identified in the system analysis.

Scope and Limitations of Research

The objectives of applying DYNA-METRIC to communication electronic equipment, and analyzing the mobile radar units in Germany were very broad. To further define the research and analysis, several limitations were placed on the study. First, only TACS units having the TPS-43 radar as the primary piece of unit equipment were analyzed. This was done because the TACS contains other non-radar elements which help to control and manage tactical fighter forces; however, these elements do not conduct the prime mission of the TACS which is providing air defense radar coverage. The overall support posture of the TACS, in general, is reflected in the posture of the radar units.

The Dyna-METRIC model developed by the Rand Corporation of Santa Monica, California, was chosen to analyze spare parts resupply for the TACS because it had the flexibility to model most components of the TACS resupply system and assess the capability of TACS units to meet their mission requirements within the limits of the resupply system. Without a reliable source of spares, the units could not operate efficiently and complete their operational mission. Changes to the system, and the resultant impact on the mission capability of TACS units, could be quickly determined by Dyna-METRIC after an initial assessment was completed.

The Dyna-METRIC model was used to analyze the effectiveness of prepositioning spare parts as opposed to prepositioning equipment end items. In 1982 USAFE proposed a prepositioning concept for equipment which would have placed spare radar and communications equipment in Germany. These equipment items would have replaced one-for-one similar items destroyed in combat at Control Reporting Posts (CRPs) and Forward Air Control Posts (FACPs). However, the proposal was not approved because spare equipment items were not available (4). This thesis analyzes prepositioning spare parts to repair damaged or broken equipment. Spare parts are more available, easier to store, and are less costly to manage while prepositioned than equipment sets.

Operating hours and demand levels for spare parts were based on scenarios where equipment was continuously turned on and off, and moved two or three times to different locations within a 30 day time period. Static equipment that operated 24 hours a day from a single location was not considered. Conclusions based on mobile units may not apply to static units.

Due to limitations in the data available, only reparable spares coded for WRSK storage and use were analyzed in the Dyna-METRIC model process. Selection of a final resupply system for all items used by the TACS assumed that whatever pipelines and procedures were established to handle reparable spares could also have accommodated all other types of items used by the TACS.

II. Literature Review

Overview

This chapter provides a description of TACS equipment and operations, discusses requirements determination for TACS spares and supplies, and reviews a small number of Air Force studies which summarize prepositioning concepts. With respect to prepositioning, most articles reviewed dealt primarily with aircraft support. The articles referenced in this chapter discuss general concepts also applicable to the radar units of the TACS. No studies were found dealing solely with prepositioning to support mobile, ground based communication/radar units.

Also reviewed were articles and reports relating how the U.S. Army uses prepositioning to support ground based forces in Europe. Because the TACS is closely aligned with the Army in Germany, tactical methods used by the Army may prove more applicable to the TACS than the strategic methods presented in the Air Force studies.

To better understand the resupply support system of the TACS, it is important to first understand the operations of the TACS. The next five sections of this chapter present an explanation of key TACS components, the organization of the USAFE TACS, its equipment, its mission, and the operational reporting of its units.

Description of System Components

(1) USAFE Tactical Air Control System (TACS) - A mobile command and control system for controlling air operations in the dynamic NATO environment. Elements of the TACS include Control Reporting Posts (CRP), Forward Air Control Posts (FACP), Message Processing Centers (MPC), Air Support Operations Centers (ASOC), and Tactical Air Control Parties (TACP). For the purpose of this thesis, when the term USAFE TACS or TACS is used, it will be refering to only the mobile radar units (CRPs and FACPs) of the TACS. There are five CRPs and ten FACPs in the USAFE TACS.

(2) Control Reporting Post (CRP) - A large mobile radar unit (approximately 230 personnel) that directs air defense and airspace control of a designated area using computer aided equipment. The CRP provides identification, navigational assistance, air-to-air refueling control, and threat warning information to friendly aircraft. It also detects and identifies enemy aircraft, assigns the enemy aircraft to either the Army Air Defense System or Air Force interceptors, and controls the intercept if required.

(3) Forward Air Control Post (FACP) - A small, highly mobile radar unit (approximately 65 personnel) that deploys forward of the CRP in order to extend radar coverage over the battlefield area. FACPs provide all services that CRPs provide, except indentification. FACPs do not have computer aided equipment for forward-tell of hostile track data.

They voice-tell all data to a CRP for insertion into the computer-tell network.

(4) Allied Tactical Air Force (ATAF) - ATAFs have operational control over elements of the TACS deployed within their area, and subsequently control TACS unit movement during contingencies. The Central Region of NATO consists of 2 ATAF and 4 ATAF, each of which is equivalent to a U.S. Numbered Air Force. The ATAF is the NATO agency responsible for controlling all air operations within their area of assigned responsibility.

(5) Message Processing Center (MPC) - A sophisticated piece of equipment arrayed with communications and data-link systems that link together CRPs to the Airborne Warning and Control System (AWACS), fixed NATO ADGE sites, and Army, Navy,and Marine tactical air control systems. This linkup allows the Air Component Commander to function as the area Air Defense Manager, and allows each user to share the others tactical information.

(6) Radio Relay (RR) - A small mobile communications unit (10-20 personnel) supplied from a CRP that establishes an intermediate point at which communications links are interconnected from various locations. Equipment used consists of mobile microwave sets and associated power equipment.

(7) Sector Operations Center (SOC) - A NATO Air Defense Agency, subordinate to an ATAF and responsible for all air

Operational instructions are passed from the ATAF to the SOC, which then relays instructions to the TACS units within their sector.

USAFE TACS Organization

An organizational chart of the USAFE TACS is shown in figure 1. The overall manager of the TACS, USAFE/DOY, is responsible for all TACS wartime planning and operations.

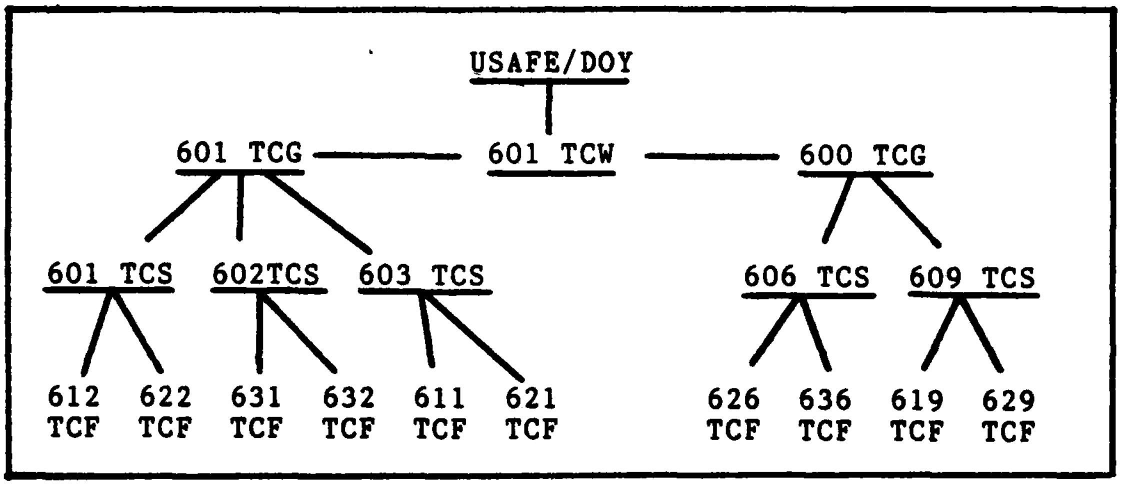

Figure 1. USAFE TACS Organization

The TACS is directly managed by the 601 Tactical Control Wing (TCW), headquartered at Sembach Air Base (SAB), Germany. The 15 mobile radar units that are under the 601 TCW are located at remote locations throughout Germany. These units are refered to as geographically separated units (GSUs) and their locations are shown in figure 2.

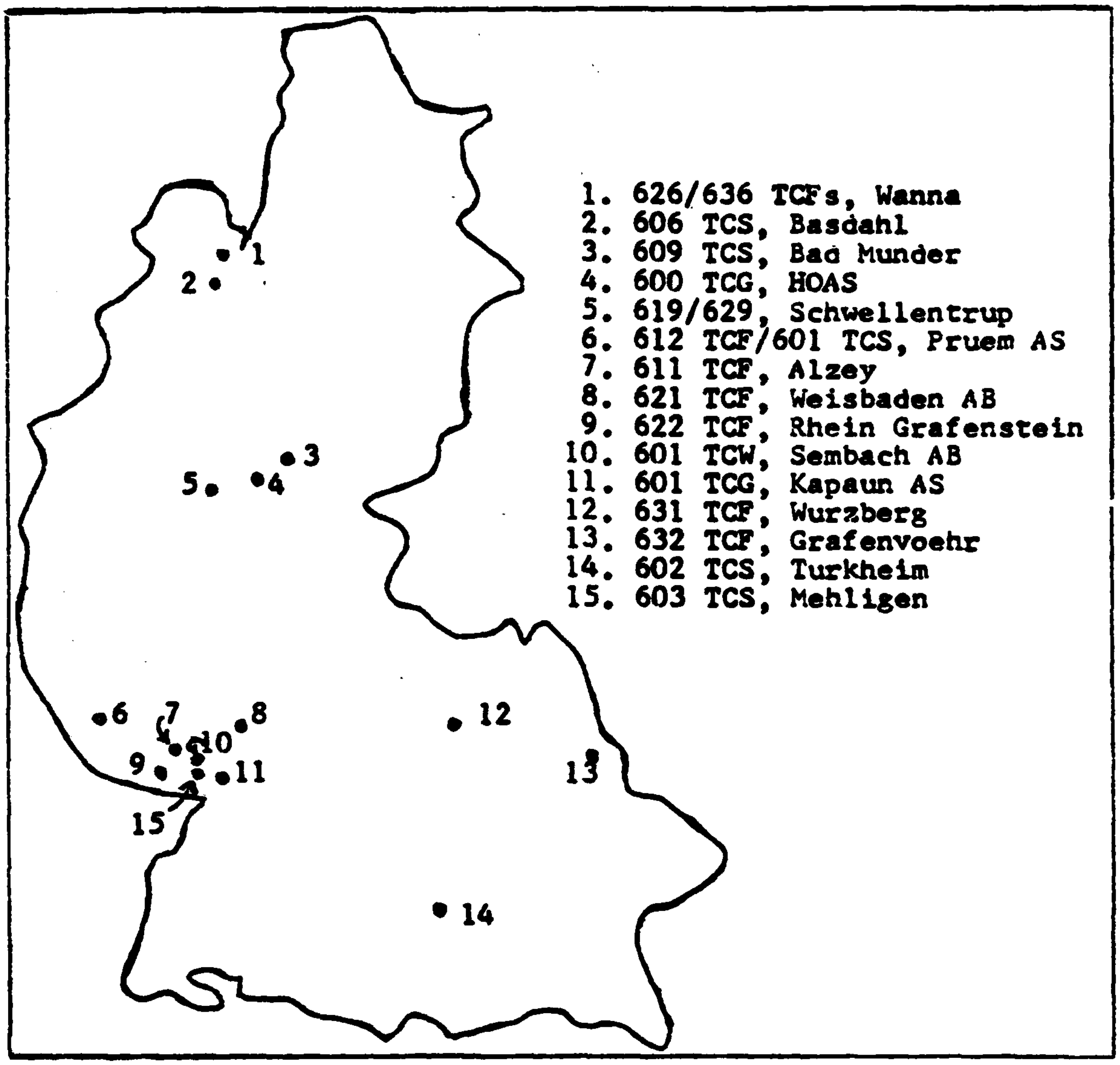

Figure 2. TACS Unit Locations

Under the 601 TCW are two Tactical Control Groups (TCG). The Northern TCG is the 600 TCG, which is headquartered at Hessisch-Oldendorf Air Station (HOAS), Germany. This group controls six GSUs (two CRPs and four FACPs). The Southern TCG is the 601 TCG, headquartered at Kapaun Air

Station (KAS), Germany. It controls the nine remaining GSUs (three CRPs and six FACPs).

As shown in figure 1 each CRP acts as a parent unit for two FACPs. The administrative chain is primarily for peacetime administration and logistical support. The operational chain is for peacetime air operations reporting and wartime command and control. When deployed, the two FACPs will locate forward of, and be linked to, the parent CRP. All CRPs will be linked to each other and the NATO ADGE. The goal is to deploy the TACS in the best pattern to provide the necessary radar coverage and back-up for the NATO ADGE system. Under this philosophy there are any number of possible deployment patterns for the TACS. Initial wartime deployment locations are classified and are specified in 601 TCW OPLAN 4102 and Allied Air Forces Central Europe (AAFCE) SUPPLAN 35001S. An example of a wartime deployment pattern is shown in figure 3.

TACS Equipment

A general knowledge of TACS equipment will be beneficial before reading subsequent chapters where TACS equipment support will be discussed. There are five types of equipment that are essential in the operations of TACS units: radar, operations shelters, power, communications, and vehicles. Although some of the equipment differs between CRPs and FACPs, much of the equipment is identical. A listing of the principle TACS equipment is provided below (7).

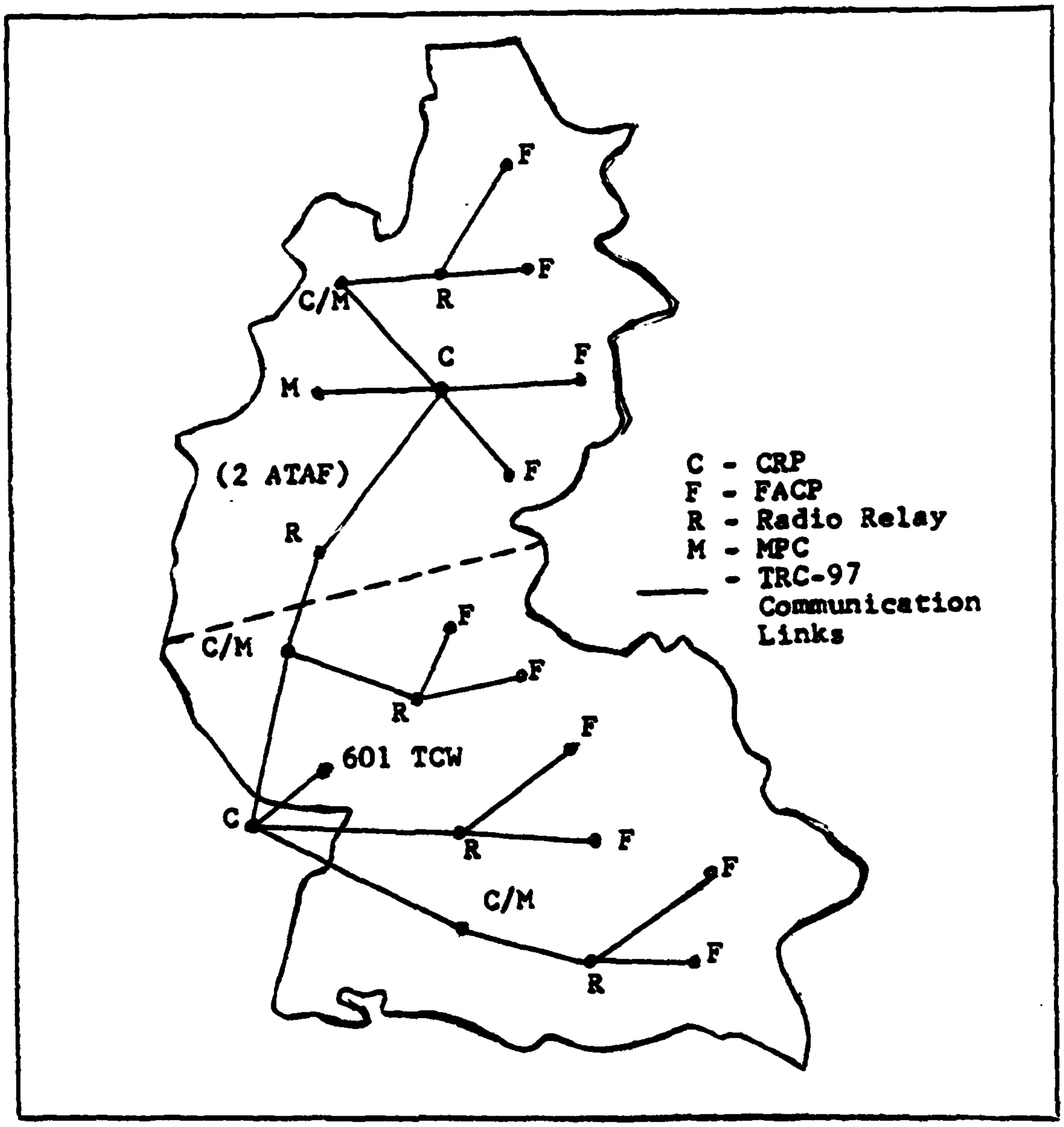

Figure 3. An Example of a Wartime Deployment Pattern

Radar. TPS-43E (CRP/FACP) - A three dimensional radar that gives the altitude, bearing, and range of aircraft out to a 200 mile radius from the radar's location.

Operational Shelters.

(1) TSC-61 (FACP) - An operation shelter that provides two control scopes from which to control aircraft.

(2) TSQ-91 (CRP) A large operations shelter comprised of 10 to 12 modules tied together with a common floor and inflatable rubber roof. It contains 14 control scopes for controlling aircraft and conducting airspace surveillance.

Power. EMU-12 (CRP/FACP) - An electrical generator which provides 400HZ power essential for the operation of all TACS equipment.

Communications.

(1) TSC-53 (FACP) - A communications van which houses UHF/HF radios, a tactical telephone switchboard, and one full-duplex teletype circuit.

(2) TSC-60 (CRP) - A communication van which houses two 1000 watt HF radios.

(3) TGC-28 (CRP) - A communications van which houses five secure full-duplex teletype circuits.

(4) TTC-30 (CRP) - A communications van that contains an automated tactical telephone switching center capable of handling 300 subscribers. Telephones are extended throughout the unit, and also to NATO and other TACS units via microwave communications links or high frequency (HF) radios.

(5) TRC-87 (CRP) - A communications van which houses four single channel and one multi-channel ultra high frequency (UHF) radio.

(6) TRC-97 (CRP/FACP) - A communications van which houses SHF radios used for establishing 24 channels over a microwave link between TACS units and other command and control centers.

(7) TSC-62 (CRP) - A communications van which houses the CRP's Technical Control Facility used for patching and testing all communications circuits both within the unit and those circuits leaving or entering the unit.

Vehicles. A variety of M-series vehicles belong to each TACS unit, and are used for carrying, pulling, and refueling the unit's equipment.

Mission

The mission of a CRP and FACP is based on the amount and types of equipment the unit possesses. The overall mission of the USAFE TACS is to 1) provide a back-up air defense command and control system to the static NATO ADGE system, 2) provide forward area surveillance and reporting to NATO air defense sector commanders, and 3) provide primary aircraft surveillance, control, and warning when static radar sites are not available. CRPs and FACPs work together to accomplish this mission, but if the information they gather can not be communicated among themselves or to NATO agencies, then their effectiveness is severely limited.

Therefore, a detailed reporting system was developed to ensure all information essential to air defense commanders is passed up the chain of command.

Reporting

In peacetime all TACS units report all actions to their respective TCG, which in-turn reports to the 601 TCW. Conversely, the 601 TCW provides operational, logistical, and maintenance direction and assistance to the TCGs and the units. However, this reporting system changes during a contingency.

When confronted with a possible contingency, operational control of the TACS transfers from USAFE to NATO (see figure 4). The time at which this transfer occurs depends on the state of alert as directed through emergency action channels. Upon transfer to NATO, all operational

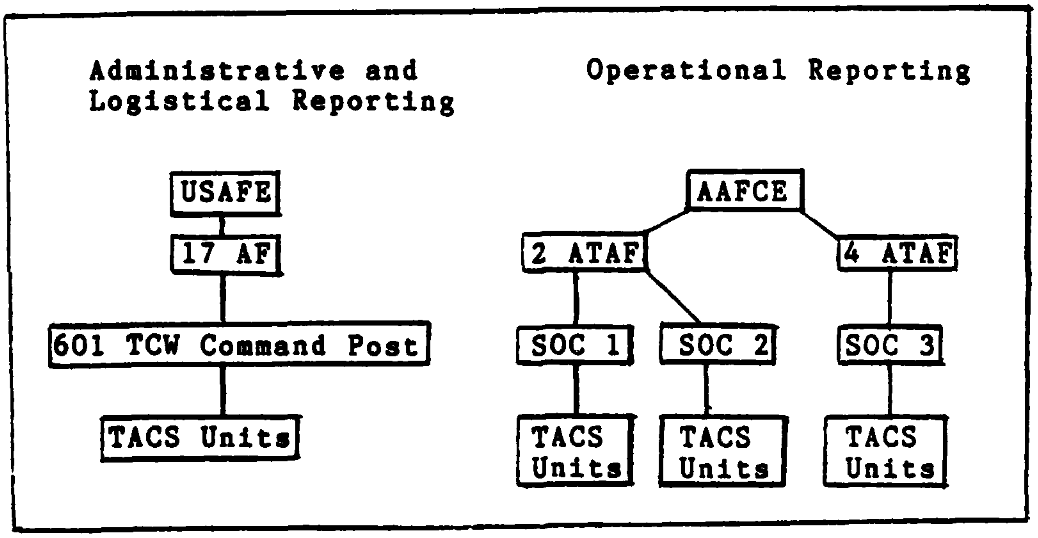

Figure 4. Wartime Reporting

reporting for TACS units is through the SOCs, which then forward the information to the ATAFs. During contingencies the 601 TCW is not in the unit's reporting chain except for matters of logistical support. USAFE and the 601 TCW remain responsible for logistical support of the TACS at all times under any circumstances. Therefore, it is important that all support planning be thoroughly developed and tested during peacetime in order to ensure efficient operations in wartime.

Reporting of any kind becomes extremely difficult for TACS units once hostilities break out. Microwave communication links, which provide the majority of voice, teletype, and data communications, may not be established or available, and radio nets may be jammed. Therefore, it is essential that all controlling agencies (USAFE, NATO, and 601 TCW) make every effort to work with each other to keep the status of the TACS as accurate and current as possible.

WRSK Requirement Determination

Because TACS units perform their wartime mission from austere locations, they depend solely on WRM for spares support following their initial deployment, and until pipelines for follow-on support can be established. Their sole source for WRM spares is the War Reserve Spares Kits (WRSK) that they carry with them when they deploy. The determination of the WRSK items and amounts is a subjective process for communications-electronic equipment, managed generally according to AFR 400-24 and AFM 67-1. The following description of the process was determined though interviews with TACS equipment managers at the Sacramento ALC, and WRM monitors at HQ AFLC.

HQ USAF directs all WRM programs and provides WRM policy. Specifically, they establish new authorizations or provide annual updates by letter to AFLC and the Major Commands (MAJCOMs) (5). USAFE/LG determines how their authorizations will be filled for the TACS through conferences with the equipment users, supply staffs, and maintenance staffs. Their recommendations are forwarded to the depot at Sacramento, where a second conference considers USAFE *requirements* with all others generated throughout the Air Force.

For aircraft systems, the demand and repair data for recommended WRSK stock numbers are fed into the WRSK/BLSS Requirements Computation System (D029) computer process to determine appropriate stock levels. For systems not supported by the D029 (such as the TACS), AFLC must manually determine appropriate levels for kit items (5:14-40A). The guidelines for these computations, and the performance goals to achieve, are in AFR 400-24, chapter 2, and are not repeated in this thesis. The recommended kit configurations and stock level data are then fed into the Recoverable Consumption Item Requirements System (D041) program at HQ AFLC, which requisitions the required items. Final configurations are coordinated and approved by the using MAJCOMs and HQ USAF (6:7).

AFLC funds, procures, and distributes all WRSK assets. USAFE, in conjunction with AFLC, arranges for storage and allocation of WRSK items among the using TACS units. Each TACS unit then stores, accounts for, inspects, and maintains their WRSK in accordance with USAFE guidance (6:8).

Problems arising from the subjective nature of this process include: constant changes to the WRSK configurations, final kit configurations being determined by system managers and not system users, kit configurations based on part demand and not storage space or mobility concerns, and finally, subjective compromises in needed stock levels because of funding limitations. The impact of these problems, and the actual ability of the WRSK to support mobile TACS units has been partially verified through formal evaluations of TACS units. When they are evaluated by higher headquarters, the units actually deploy to austere locations and simulate wartime operations. Inspection reports from USAFE and AAFCE have reflected the following problems:

(1) Units were unable to declare themselves at least partially mission capable within time limits established in the evaluation scenario because of broken equipment and parts not available in the WRSK to fix the equipment.

(2) Levels on some spare parts were not adequate to meet the operational demands of the scenarios.

(3) Inadequate storage space existed to accommodate the WRSK, making it doubtful units could operate on WRSK alone.

Several solutions exist to resolve these problems, but this thesis will only evaluate intra-theater prepositioning of WRM as a potential solution. Before discussing the specific methodology used to evaluate prepositioning, this chapter will conclude with an overview of prepositioning concepts and techniques employed by the Air Force and Army in the European theater.

Prepositioned Stock

The DOD identifies prepositioned stock (PPS) as WRM. Specifically, it is that materiel essential to the execution of initial wartime missions that is prepositioned to assure timely support until replenishment can be effected (6:4). This prepositioned stock includes supplies, equipment, fuel, ammunition, vehicles, medical supplies (i.e., whatever is necessary to meet the essential needs of combat forces). The PPS is stored in or near the area where a probable contingency may occur depending on such variables as warning time, unit readiness, security, facilities, distribution capability, and survivability (6:6).

For this thesis, PPS will mean any items stored away from a central base supply and located closer to combat areas in support of mobile units.

What to Store and Where to Store It. DOD has established guidelines on what to consider for WRM stockage. Because PPS is WRM, the question of what to store for TACS units should be answered within the DOD requirements. These are summarized in AFR 400-24 as:

(1) Items essential for combat forces to:
   a. Provide battlefield protection of personnel.
   b. Detect, locate, and maintain surveillance of the enemy.
   c. Communicate under wartime conditions.

(2) Items essential for the operational effectiveness of combat forces and the expanded logistics system in support of combat forces. Items contained in this group include those applicable to contiguous transportation and the support of men and material, and for the establishment or construction of logistics bases, port facilities, hospitals, etc.

(3) Items without which essential equipment or weapons systems would be inoperative or operationally ineffective.

(4) Items essential for sudden mobilization and/or deployment of approved active and reserve forces, e.g., initial equipping, housing, and training of reserve forces.

(5) Items required for survival and protection of personnel, e.g., medical supplies and equipment, certain air/sea rescue items, and items designated as operational rations. (6:4)

Tattini (1977) discussed management of the WRM item selection process. He felt that "the majority of senior level management attention has been focused on the criteria for selection and justification of items to be placed in WRM storage, leaving the equally critical area of theater and base-level management without adequate attention (22:11)." By directing attention to the theater and base level, Tattini brought focus on the operating level where PPS is stored, used, and impacts most on the ability of forces to wage war.

The decision by MAJCOM and base commanders of where to store PPS in theater becomes equally as critical as the higher level decisions of what to store. Hollums (1983) recommended moving Other WRM (OWRM) now stored in CONUS to prepositioned locations in Europe and Asia. He addressed the operational impact of the OWRM, and reasoned that the moving of the stock out of CONUS to Europe and Asia would, "support weapons systems already assigned to the theater as well as those weapons systems, which according to current warplans, are designed to deploy to the theater (11:49)."

Hollums seems to encourage the idea of making WRM stock fully available in the areas where needed. Strategically, this means moving them from the CONUS to potential wartime theaters. Tactically, the stock must be placed in theater to allow for rapid access and use. Rainey (1966) addressed the tactical environment in his study. He felt support of combat operations was difficult to analyze because of the "highly variable needs of the ground and air units engaged in combat." He explained that in a fluid combat situation the quantity of resupply can change drastically, the composition of demands changes, and the locations at which supplies are needed changes frequently (19:22). Where to store PPS (other than WRSK kits) to meet the needs of TACS units in the fluid environment of Central Europe will be developed and supported more fully in later chapters of this thesis.

Related to the where and what of prepositioning is the critical factor of risk. Hollums quoted General Billy M. Mentor, AF Deputy Chief of Staff for Logistics on the subject of risk. He stated:

> There's a question of how much of what should be prepositioned... there's a real risk it'll be destroyed before we arrive. There's also a "political risk." There are cases where it may not be politically feasible to extract...and that presents a problem. Even so, if the nation has a vital interest (in a particular area), it's probably acceptable to put (things) at risk by prepositioning...like most everything else in logistics, it's a balancing act. (11:34)

Prepositioning spares for TACS units in Germany may work to cut down the risk involved with storing the vast majority of all stocks at SAB. Two or three widely separated PPS locations may be more survivable than the single base supply at Sembach.

Potential Cost. Rainey discussed prepositioning costs in his Rand study. He saw prepositioning as "a change (at cost) of the distances which forces or their equipment must be moved which, other things being equal, will increase rapid response capability (19:15)."

He discussed cost tradeoffs with respect to location and size of PPS, then listed costs incurred with any prepositioning scenario. Principle cost tradeoffs concern the acquisition and storage costs of operating and acquiring the transportation to support a system from a more centralized supply. The costs, whenever incurred, include cost of storage, periodic replacement of shelflife items, maintenance of serviceable items (i.e., TCTO), and protection against sabotage and pilferage. He concludes by noting that "if the cost of supporting and distributing the PPS are more than offset by the benefits of having some of the force closer to its potential wartime location, then a posture which includes more prepositioning would be prefered (19:15-16)."

U.S. Army Prepositioning Concepts. Throughout the DOD, all services use prepositioning to enhance the readiness postures of their forces in potential combat theaters. The greatest differences in methods are primarily due to location, mission, and accessibility to the theater.

The Army is the leader in inter- and intra-theater prepositioning techniques, especially in Europe. Their Prepositioning of Materiel Configured in Unit Sets (POMCUS) program is an ideal model of strategic prepositioning. The objective of the POMCUS concept is to allow for the rapid deployment of combat forces by prepositioning equipment for them in Europe, and then flying the personnel from CONUS to operate that equipment in time of war. The equipment is kept in climate controlled warehouses in an armed, fueled, and ready-to-go configuration (20).

Ringold (1981) explained the Army's intra-theater tactical management of resupply stock. He discussed procedures to sustain corps fighting strength until the arrival of CONUS based resupply. This includes the subsequent support after initial issue of POMCUS assets, and until pipelines are established to the CONUS. The concept is called preplanned supply and is managed by storing equipment and major subassemblies (guns, radios, etc.) in complete corps packages. Each package is "ready for use" and can be pushed to the combat units to provide immediate support (20:17-18).

Sullivan (1983) discusses another tactical supply concept useful to the TACS, that of central "supply points" in combat areas. Wartime supplies would be pushed to these locations in advance (and stockpiled if necessary) until pipelines were established to major supply sources (21:7-8) Essentially the PPS concept proposed to support the TACS fits the forward supply point concept used by the Army.

Summary. Prepositioned stock is WRM and should be managed according to DOD and service regulations. For the TACS, prepositioned stock would be stored away from SAB, closer to the locations where TACS units will deploy for war, similar to forward supply points used by the Army in Europe. What to store at these sites will be according to DOD guidance on designating materiel as WRM. Where to store it will be developed in subsequent chapters. Although there are certain costs associated with holding and maintaining the stocks, as well as risk to hold the stocks in potential war zones, the improved readiness of having stocks closer to units when needed may offset the costs incurred.

III. System Analysis

Preface

The TACS is a very dynamic system. Once engaged in a contingency, its wartime deployment configuration will be constantly changing. Some units will be operational, while other units are on the move. Upon arriving at new locations, the deploying units will become operational, while other units begin redeploying. Communication links will also be in a constant state of reconfiguration to accommodate moving units. Because of this dynamic environment, the resupply system which supports the TACS should be flexible and responsive to ensure that it will provide an adequate level of support.

A combination of two methodologies was used to investigate the problem of providing an effective resupply system for the TACS. The authors felt all aspects of this dynamic system must be evaluated before a final resupply system could be recommended. The first method consisted of a system analysis of the TACS resupply structure to try to determine the "best" resupply system for supporting the TACS. Systems analysis is a well accepted research method. It concentrates on analyzing the system as a whole, examining the relationships within the system, and the environment in which the system must operate. Qualitative considerations, more than quantitative ones, were drawn from the application of this methodology.

A second, more quantitative methodology, involved using the Dyna-METRIC model to analyze the resupply system for TACS spare parts. The model was used to compare the current resupply system to a possible prepositioning system. A detailed explanation of how this methodology was used is presented in Chapter 4.

Overview

This chapter presents the system analysis of the USAFE TACS. It will show how the authors arrived at the selection of the prepositioned stock proposal presented in Chapter 1. Chapter organization is according to the five classical phases of a system analysis. First, the conceptualization phase examines the resupply system in detail. Major topics of discussion in this section include the scenario under which the TACS must operate, the operative elements, the relationships between the elements, clarifying system objectives, and finally, the criteria by which the resupply system is evaluated. The second phase is searching for alternatives. Its purpose is to identify all possible courses of action which can improve resupply system performance. Evaluation, the third phase, analyzes the various alternatives against the performance criteria established in phase one. The fourth phase, interpretation, draws conclusions and findings from the previous phases, and then selects the most suitable alternative based on the conclusions. In the final phase, verification of the selected alternative is attempted through testing.

Phase 1 - Conceptualization

Scenario. The proposed scenario for a war in Europe is fairly well known and publicized. Due to a world event, or simply by surprise, the forces of the Soviet Union and their Warsaw Pact allies may pour across the East German and Czechoslovakian borders into Central Europe. The invasion will be spearheaded by massive, concentrated air strikes along several corridors. Primary targets of the initial air strikes will include command and control systems (such as the TACS and other air defense radars), commercial and military communications installations, and air bases. Those targets not destroyed initially will be jammed by the sizeable Soviet electronic combat contingent in an effort to render remaining systems useless. Throughout the initial Soviet thrust, NATO forces will maintain a defensive posture, holding on until additional forces can arrive.

The mission of the TACS, as discussed earlier, is to back-up the fixed NATO Air Defense System Ground Environment. It is at this critical time in a European conflict that the TACS must be fully capable of performing its mission. Under the scenario described above, the TACS would move into operation upon notification by USAFE/NATO via emergency action channels. TACS units, at their home station (garrison) locations, would teardown and deploy to an assembly location to await further instructions. Depending on the state of alert, at some point in time operational control over the TACS would transfer to NATO. At their assembly locations, units will begin to receive movement orders through NATO channels. The length of time a unit may wait at an assembly location will depend on the effectiveness of initial Soviet advances. Units may remain at assembly locations for days, or they may move immediately once the entire unit is assembled; it all depends on the combat situation.

If the combat situation is unfavorable to U.S./NATO forces, TACS units will be directed to deploy immediately to preselected operating locations, or other holding areas, as directed by NATO. As units arrive at their operating sites they will begin equipment set-up under an emission control status called EMCON silent, that is, not radiating any radio or radar emissions. Units will only radiate upon direction from NATO, and then only radiate when mission essential. Thus they could sit for long periods of time in EMCON silent at an operational site before being used. As units are used, and after a certain amount of time radiating from one location, they will be directed to redeploy to new locations. This constant moving helps to ensure the survivability of the individual TACS units. Limited radiating time and constant movement will become a way of life for each unit, especially if the Warsaw Pact forces continuously target command and control systems.

This is the scenario under which the TACS must be capable of operating. Throughout this scenario supplies and spare parts are being consumed at unit operating locations, which creates a need for a flexible resupply system. The resupply system must be capable of operating and surviving in the dynamic combat environment of the TACS.

Operative Elements. Operative elements for the TACS resupply system are defined as those elements within the resupply system, in which changes can be made that either create a positive or negative effect on total system performance. Figure 5 depicts a model of the resupply system currently used by the 601 TCW. The operative elements in this model are base supply and distribution.

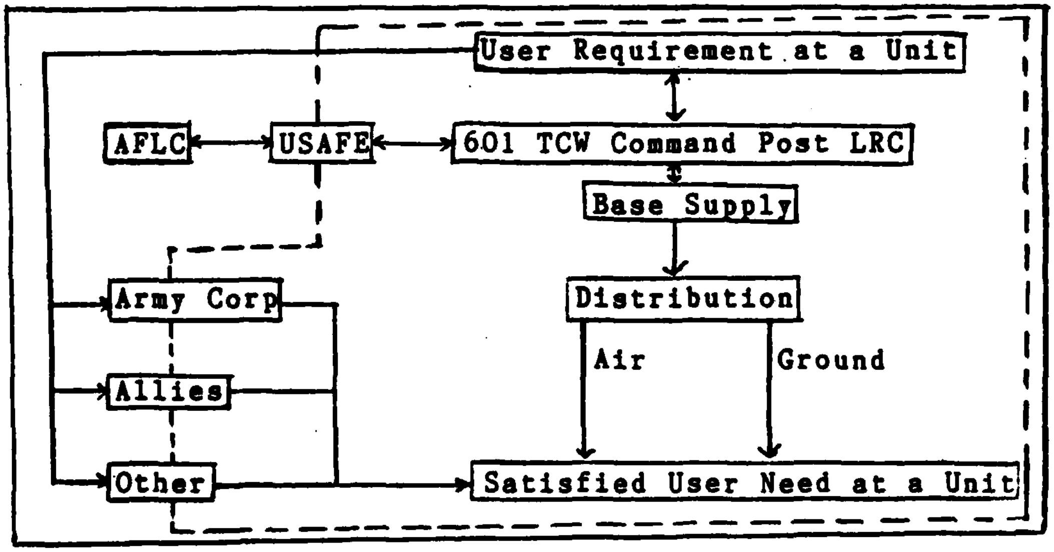

Figure 5. Resupply System Model

It is through changing the operative elements that system performance can be enhanced.

Element Descriptions. Through investigation of the relationships between the elements shown in figure 5, many of the dilemmas faced by the TACS units begin to surface. However, before discussing these relationships, each element in the model will be discussed separately, so its relevance to the model can be fully appreciated.

(1) User Requirements - These are the needs of each TACS unit for spare parts and other support supplies required to keep the unit operational. Required items can include anything from toilet paper to major equipment end items. Requirements are satisfied from various sources, depending on the type of item needed.

(2) 601 TCW Command Post Logistics Readiness Center (LRC) - The point to which all TACS unit requirements are passed. It is the single point within 601 TCW at which resources (if available) can be allocated to units to satisfy needs.

(3) 601 TCW Base Supply (Sembach) - The single facility within USAFE designated to provide supply support for the TACS, to include demand processing, WRM management, materiel control management, warehousing of supplies not stored at the units, and overall supply guidance to the TACS units. They directly support 9 radar units in Southern Germany. The remaining 6 radar units in Northern Germany are sup-

ported through a base supply satellite account at HOAS (5:601 TCW Supplements).

(4) Distribution (Sembach) - The transportation processes within 601 TCW that are charged with getting needed items to the requesting units. Resources include CH-53 helicopters assigned to the 601 TASS and vehicles managed by 601 Transpo-tation Squadron at SAB.

(5) USAFE - Overall manager of the TACS; ultimately responsible for all TACS logistical support.

(6) AFLC - The controlling agency for all TACS equipment. AFLC depots repair all TACS equipment that can not be repaired at the unit locations. All base level maintenance for TACS equipment is performed at individual unit locations. No repair capability exists at Sembach, and no intermediate repair facilities exist for TACS equipment in Europe.

(7) Army Corps - Central Europe is divided into regions which are defended by Allied Army corps. These regions range from the Dutch, German, and British Army corps in the North, to U.S. and German Army corps in the South. Subordinate to each U.S. corps is an Air Liaison Officer assigned to coordinate USAF and Army combined operations. TACS units may possibly coordinate logistics requirements for provisioning support items through the corps in the area in which they are located. Such requirements may include:

fuel, food, and clothing. Spare parts requirements must still go through base supply at Sembach.

(8) Allies - As with the U.S. Army corps, TACS units will be operating in close proximity to, and supporting our NATO allies. Possible support could be sought through these units, and in fact some TACS units have already developed unilateral support agreements with British and German corps.

(9) Other - In time of war, supplies can be taken, as needed, from the surrounding communities to sustain the combat capability of the units. Such actions would be requested through, and approved by the German Territorial Command.

System Relationships. The explanations for each of the above elements was simple and direct. However, the interactions of these elements in the Central European environment are anything but simple. Complications arise because of the conditions under which the TACS must operate (as highlighted in the scenario), and the dual chain of command they employ under, NATO or U.S. Having the units separated from their source of supply by up to 300 miles further complicates the system. Since Sembach AB is the sole source for the majority of spares and supplies for the TACS, a loss of base supply could, in essence, bring the resupply system to a standstill. The remainder of this section will discuss the relationships between elements and the complications that exist among these relationships.

(1) User Requirements to 601 TCW Command Post LRC - This relationship is a two-way interaction by which all logistical support is conducted through the 601 TCW command post. Units identify their needs to the LRC in any number of ways: by commercial or military landline, by HF radio communications, or by the tactical telephone network (TTC-30) extended over microwave (TRC-97) links. Although many communication modes exist, all will have their limitations. Once hostilities commence, the German government will control the commercial telephone system, and restrict dial-out capability to only key users such as military bases, police, hospitals, and fire stations. TACS units will not have access to these controlled phones because of their remote locations. Units will have access to the tactical telephone system, which is very effective and dependable when fully operational. However, units may need to transmit their calls via nine or ten intermediate microwave links to reach the command post. All of these links may not be established or operational, or they may be redeploying themselves to accommodate moving radar units. The most reliable way to request supplies is by formatted messages passed over the 601 TCW HF radio network, but problems arise here also. Airways that are now congested in peacetime, will be even more congested in wartime. The 15 radar units, plus radio relay units, and other non-radar elements of the TACS will all need to use the HF network at the same time. In addi-

tion to the heavy congestion, jamming is also expected from the Soviets and the Warsaw Pact. This communication problem is further amplified by the fact that not only do units have to contact the command post, but the command post has to be able to contact the units to request status as well as other operational matters.

(2) User Requirements to U.S. Army Corps, Allies, and Others - This relationship is, to a large extent, just beginning. While several TACS units have self-initiated formal and informal agreements with other U.S. or NATO services on obtaining needed supplies through their units, the warplans that will require these agreements are now in the coordination process. In the past, it has been assumed that the TACS could get needed supplies, except spare parts, from these sources. Even if they could, problems still occur in that, like the TACS, these sources will be continually moving; therefore, just locating them to get supplies will be difficult. Additionally, common frequencies among the services do not exist, and in most cases the radios used by the other services and NATO allies are not compatible with those used in the TACS. No communications links are planned to these sources, so contacting them will probably be more difficult than contacting the 601 TCW command post. Even if contact can be established, language differences remain a major obstacle.

(3) Army Corps, Allies, and Others to Satisfied User Needs - If contact can be established with one of these services, and supplies can be provided, then the requestor will have to arrange for the delivery of the supplies. As already mentioned, both parties may be on the move at the same time which may make delivery difficult. But if this obstacle can be overcome, then many of the resupply needs of the TACS could be met.

(4) 601 TCW Command Post to USAFE - This is a two-way relationship, in which each agency keeps the other informed on the current status of the TACS. USAFE is in direct contact with NATO authorities, and acts as their advisor on TACS matters. The 601 TCW is in direct contact with the units. Together both agencies try to maintain the most accurate picture of the TACS situation. Logistical support problems that are beyond the scope of 601 TCW to deal with are passed on to USAFE to be handled by their logistics staff.

(5) USAFE to AFLC - This relationship is necessary because AFLC has sole maintenance responsibility for TACS equipment beyond the unit level, as there are no in-theater repair facilities for TACS equipment. AFLC is also the source for additional TACS spare parts. Although there is a peacetime relationship, in time of war it may be immaterial since the leadtime factor for receiving stateside depot service (estimated 4-6 weeks) may be too long to be of any

use. U.S. airlift assets will be totally committed to moving initial combat supplies and troops into the theater of operations after hostilies commence. It will probably be 30 to 60 days before the resupply pipeline to stateside depots will be fully established.

(6) 601 TCW LRC to Base Supply - This two-way relationship deals with determining if requested spares and supplies are available. Requests are forwarded from the LRC to base supply who, in turn, processes the order and notifies the requesting unit (via the LRC) of the action taken (i.e. fill, kill, or backorder the request).

(7) Base Supply to Distribution - This relationship develops if requested supplies are on hand which then need to be delivered to the requesting unit. Base supply, upon finding that requested supplies are available, then contacts distribution personnel whose responsibility it is to get the supplies to the requesting unit.

(8) Distribution to Satisfied User Need - Distribution from the warehouse at Sembach AB can be either by ground or air transportation. As mentioned in Chapter 1, severe restrictions are placed on transportation of any kind during a contingency. These restrictions, coupled with the problems of locating the requesting unit (see page 2 chapter 1) for delivery in a timely manner, may be the single largest factor in making the resupply system ineffective. Although CH-53 helicopters could provide efficient service, air re-

strictions and the limited number of aircraft severely limit their reliability in delivering materials to satisfy unit needs.

Before leaving this phase of the analysis it is appropriate to discuss briefly the model boundaries and environment. The boundaries of the resupply system are shown by the dotted lines in figure 5. The area inside the dotted line represents the area in which the 601 TCW can influence system operation. For those elements bisected by the boundary, (USAFE, U.S. Army Corp, Allies, and Others) the 601 TCW can assert some level of influence. Certainly 601 TCW staff expertise can influence decisions and plans made at the USAFE level. Additionally, 601 TCW can, through its own initiatives, work to develop agreements with the Army, Allies and others in matters of TACS resupply.

The environment of the system consists of those factors that can effect system behavior, yet cannot be controlled or influenced by 601 TCW. The environment includes, but is not limited to such things as: Air Force and USAFE level desires, NATO politics, limited resources, old technology, and the dynamics of the combat situation. Since the environment represents uncertainty, any actions taken to reduce environmental uncertainty will be beneficial to TACS resupply system performance.

System Objectives. The objective of the TACS resupply system is to provide supplies, needed by operational TACS units, in a timely, responsive manner to ensure these units do not go non-mission capable for lack of supply support (NMCS). To see if this objective is being attained, various resupply alternatives will be evaluated against the following criteria.

Criteria to Evaluate System Performance. Evaluation criteria used by USAFE and AAFCE provide the only measurement objectives now in use to evaluate the effectiveness of TACS resupply. During formal evaluations by USAFE/AAFCE, TACS units are deployed to the field for 2-4 days under simulated combat conditions. Although the supply, materiel management, and site support functions are inspected during these formal evaluations, the short time span which the unit is in the field never allows for a full test of the 601 TCW's ability to resupply the units. In most cases, if an item is needed through base supply the process of ordering through the LRC and having the part delivered from SAB is simulated, due to cost and time constraints. Therefore, the wartime resupply system has never really been evaluated under simulated wartime conditions.

The following four areas summarize the criteria currently used to evaluate individual TACS units, and will be used in this study to evaluate proposed resupply alternatives. Exact USAFE/AAFCE criteria were not used because they apply to individual unit performance, while this thesis is evaluating the overall system performance of many units at one time. These criteria are: 1) responsiveness to user request, 2) survivability of the resupply system, 3) the minimization of uncertainty in the resupply system, and 4) the ability of 601 TCW to maintain and manage the system.

From the standpoint of the unit, the most important aspect of the resupply system is its ability to meet the units' requested needs in a timely manner (responsiveness). This can be done by minimizing the time from order placement by a unit to the time they receive the requested item. To be effective, the responsive system must be able to survive the destructiveness of war. For the TACS to remain operational, the resupply system must also remain operational, even if parts of the resupply system are destroyed.

Uncertainty in the resupply system compounds the problems of commanding a TACS unit. Minimizing uncertainty adds a sense of reliability and stability to the system. To a TACS unit commander, the less uncertainty the better he can manage the unit's operations, thus increasing overall unit efficiency.

The final criterion, the maintainability of the resupply system by 601 TCW, is essential because no other organization, U.S. or NATO, can pick up TACS resupply responsibilities if the 601 TCW fails in its efforts to keep the system operating. The 601 TCW must have all the personnel, equipment, and facilities needed to operate the resupply system under its control. Additionally, any resulting resupply system must be manageable by the wing in its entirety. Therefore, it is appropriate that this criterion be a key consideration in evaluating system performance.

Phase 2 - Alternative Resupply Systems

Six alternative resupply systems are identified, and discussed in this section. The alternatives presented were derived by making changes in the operative elements which could enhance system performance to some extent. More alternatives exist, but these would require changes in areas other than the operative elements, and may go beyond the capability of the 601 TCW to implement, both from cost and resource availability standpoints. As highlighted in chapter 1, one of the objectives of this thesis is to recommend an improved resupply system for the TACS based on the 601 TCW's ability to implement the system with its existing resources; therefore, only alternative systems that meet this condition will be considered. Alternatives that rely heavily on other services or allies were also not addressed. The old addage "every man for himself" is a perceived truism in time of war. As a result, the alternatives most feasible for the TACS are those that can be operated and maintained solely by the 601 TCW.

Alternative 1. The first alternative is to leave the existing system as it is, but work with all the elements within the boundaries of the system to minimize the problems existing within the relationships.

Alternative 2. Alternative 2 is to increase stock authorizations for equipment, spare parts, and life support items, and then fill the authorizations so sufficient quantities exist at the onset of a war, and thus minimizing the need for a resupply system.

Alternative 3. Alternative 3 requires the break-up of the single main source of supply at Sembach AB into multiple elements. Breaking this function out to three locations (one Northern, one Southern, and one at Sembach to service the Central region) would increase responsiveness and suvivability, and add more certainty to the resupply system.

Alternative 4. This alternative is to reduce TACS unit movements, and limit their potential operational locations to U.S. and allied air bases. In this manner resupply could be integrated with existing interbase supply systems, thus increasing system responsiveness and reliability while at the same time reducing uncertainty for unit commanders.

Alternative 5. Alternative 5 is to improve the distribution element of the resupply system by dedicating transportation resourses, both personnel and equipment, to support the TACS. Provided these resourses can be made available, regular routes and schedules could be precleared with NATO authorities. This action would seek to reduce response time and add to the 601 TCW's ability to maintain the resupply system.

Alternative 6. This alternative is a combination of the other alternatives, drawing on their best features to improve system performance. Specifically, alternative 6 would be to break-up the base supply element and improve the distribution element. Resupply points would be established as in alternative 3, and be stocked with a minimum of 30 days of supplies. The distribution element would be set up as discussed in alternative 5, but would only service the resupply points instead of the individual TACS units. The net result may be improvements in all four criteria areas.

Phase 3 - Discussion of Alternatives

Alternative 1. While this alternative may be the easiest one to implement, evaluating it against the criteria shows that only slight improvements may be realized. By working with USAFE and NATO agencies, the problems of transportation clearances and communications may be resolved to some extent, but certainly not eliminated. Refinement of procedures, and practice in using those procedures may also help to improve responsiveness and maintainability. The problems of uncertainty and survivability would remain unchanged.

Alternative 2. Increasing authorizations, so units are self-sufficent for a minimum of 30 days, would most assuredly improve system performance. The emphasis on responsiveness and maintainability of a resupply system would be almost eliminated since individual units would be self-sufficient to a large extent. Uncertainty for unit commanders would be reduced since they would not be so dependent upon a resupply system to keep the unit operational.

This enhancement improves system survivability since the resupply system only needs to be able to respond to emergencies during that first 30 day period of the war. The resupply pipeline needed beyond 30 days would have time to develop based on the combat situation, and there would be ample time to coordinate the pipeline resupply system with the appropriate NATO agencies.

Ideally, this alternative solves many of the problems faced by the TACS. Increased authorizations for radars, radios, and power equipment end items would add a back-up capability for the TACS, where none currently exist. Increasing vehicle authorizations would allow the unit to carry more fuel, spares, and life support assets. Spare part increases would ensure rapid repair capability within each unit, thus enhancing the units operational capabilities. Together, these increases would take the pressure off the resupply system; however, the feasibility of implementing this alternative now is low due to cost and equipment availability constraints.

TACS equipment is old and most of the major end items are no longer in production. The equipment that is available is in short supply. Virtually every TACS unit does not now meet its existing authorization in both major equipment end items and vehicles. Spare parts are also in short supply. Storing spares, other than WRM, at Sembach best serves the interest of all units in peacetime because units do not have room to store much stock beyond their WRM at their garrison locations. Units draw from Sembach as needed, and the probability of spares being available when needed is higher, since they are not distributed sparsely among the units. However, the biggest drawback in this area is that the majority of the TACS spares are stored at Sembach in a single warehouse facility, and the loss of this facility would seriously impact on the TACS mission capability. Increasing provisions, although desirable, only adds to unit transportation problems. Units barely have enough vehicles to pull and carry their current authorizations. Without additional vehicles, adding more items would be senseless.

Although the feasibility of increasing authorizations does not look productive in light of the current TACS, it should be considered as USAFE begins replacing older TACS equipment through forthcoming TACS enhancement initiatives. Much of the current TACS equipment is being replaced in the 1986-90 time frame. The merits of this alternative are greater when applied to replacement buys. Incorporating it early in the procurement process would heighten future TACS system performance.

Alternative 3. Removing sole source responsibility for TACS resupply from a single point at Sembach to multiple forward operating locations has the potential to improve the system in all four criteria areas. Implementation would require selection of the forward locations, and plans to operate at these locations.

Since maintainability of the resupply system is one of the evaluation criteria, using locations already controlled by 601 TCW for forward resupply points would be the logical consideration for site locations. Selecting points away from the inter-German border toward the western part of the country would make them more useful and survivable in the event of some advancement into Germany by opposing forces. Other considerations for site selection include: existing facilities to store the forward stocks, sites that can be accessed by all TACS units they would support, and sites centrally located with respect to the units in the region they would support.

All TACS garrision locations are possible forward stock sites, but they do not meet all the previously mentioned requirements. Some suggested locations that meet these requirements are: 606 TCS at Basdahl or Hessisch-Oldendorf AS in the Northern region; Sembach AB, Wiesbaden AB, or 611 TCF at Alzey in the Central region; and 602 TCS at Turkheim in the Southern region.

This thesis only evaluates the potential for forward stock location to improve the wartime resupply system. Exact locations for forward stocks are not evaluated, nor recommended. These evaluations should be accomplished by USAFE prior to adopting a forward stockage policy.

Assuming additional resupply points are established, the benefits realized by this action are many. Survivability of the entire resupply system is enhanced. Destruction or loss of one point may limit the activities in a region, but would not result in total system disruption and loss of all TACS needed supplies.

Responsiveness to user requests may also be enhanced. Most of the predesignated wartime radar sites would fall within at least a 75 mile radius of one of the resupply points. Units could pick up their supplies as they are needed because distances between the supply points and the units are substantially reduced. Even with the wartime restrictions, TACS units could utilize secondary roads efficently over these shorter distances. Other benefits derived from this method are the units not having to communicate with the resupply point or the 601 TCW command post to coordinate resupply, and the units not having to wait for supplies to be delivered.

Unit commanders' uncertainty is reduced under this alternative. Published warplans could include resupply point locations, and define the regions they support.

Details could be included on alternative actions to be followed in the event one or more of the resupply points are destroyed. The point is that now the commanders would have some knowns: they would know where to get supplies under any circumstances, know that these facilities can supply the majority of their needs, and know that they pick up their own supplies as they need them. Together these knowns reduce the uncertainty that previously existed for commanders.

Implementation of this alternative would require some restructuring of personnel and facilities within the 601 TCW. To establish this type of resupply system for wartime, consideration of using it in peacetime should also be evaluated. The greatest benefit of peacetime use is the practice and training received as a result of "training the way you are going to fight", a concept that is emphasized at U.S. and NATO headquarters. Collocation of the resupply point at an existing TACS site location involves enhancing existing storage facilities, and redistributing base supply personnel from Sembach to each site. These actions are within the scope of the 601 TCW and USAFE to implement. As a result, 601 TCW would have an increased ability to maintain a resupply capability for the TACS during a contingency. Sembach base supply would remain responsible for all 601 TCW supply functions, but would support the TACS through two or more forward supply points. TACS units within each region would work through their respective forward supply point in all matters of supply, both in peacetime and wartime.

Alternative 4. Assuming radar site locations at allied and U.S. air bases can be evaluated for radar coverage adequacy, and air base sites are selected that only provide adequate radar coverage, then several advantages to this alternative arise. First, units would not have to move as frequently because they would have the advantage of the increased security afforded to air bases. Secondly, TACS resupply for such items as food and fuel could come from stores existing at each base. Lastly, other resupply requirements could be integrated into the proposed European Distribution System (EDS) of which Sembach AB is one of the participants. The availability of an airbase runway adds many possibilities that do not exist for TACS units that are located at austere locations. With a few dedicated aircraft, resupply could be conducted using Sembach AB as the hub, even if the TACS is not integrated into EDS.

These advantages enhance system maintainability and security. Less frequent moves, increased security, and known sources for resupply help reduce uncertainty for commanders and increase responsiveness to user requirements. Prepositioned stocks and air transportation contribute to the reduced time it takes to meet unit needs.

However, a drawback to this alternative, as with any resupply system tied to an air base or fixed facility, is the fact that these installations are prime targets. Even with increased security, the enemy is sure to concentrate a high percentage of its efforts against these installations. Another drawback is that the gap-filler radar mission of the TACS could be degraded. Restricting unit movements and operating locations could severely restrict the TACS from meeting their stated mission objectives. A TACS unit must be free to move to the location which provides the best opportunity for coverage of their assigned surveillance area. NATO assigns surveillance areas and may not support any actions that put restrictions on unit movement or operating locations.

Alternative 5. Improvements in the distribution system would enhance system responsiveness and help to reduce uncertainty for unit commanders. The key to implementing this alternative is to dedicate transportation personnel and equipment to the TACS resupply mission.

Dedicated vehicles and personnel should be made available and responible for providing all peacetime resupply support as practice for performing their wartime support mission. Presently, individual TACS units either come to Sembach to pick up supplies, or supplies may be delivered by Army transportation, or supplies are delivered by a weekly supply run from Sembach. Since these methods will not be used in wartime, they should not be used as the primary means in peacetime. Regular runs are now in exsistance and standardized to support peacetime garrison locations, and could be modified to support wartime locations. Wartime routes can loop through several units at a time, so a large vehicle fleet is not necessary (estimate 5 to 8 M-35 trucks and 20 to 25 personnel). Assigned personnel would become familiar with the country-side and highways (primary and secondary) thus increasing the probability that they can locate TACS units once they have deployed.

As the peacetime system begins to function smoothly, wartime route planning can take place for regions where the TACS will be deploying. These routes can be worked through USAFE, and recommended to NATO to get them precleared for wartime use. Not only should ground transportation resources be dedicated, but so also should air assets.

The CH-53 helicopter squadron at Sembach AB could be dedicated solely for TACS support. This is supposed to be the case now, but since this unit is the only USAFE controlled helicopter squadron, it performs many other tasks outside the 601 TCW. While this may be acceptable in peacetime, the 601 TCW must know that they would have dedicated helicopter support in wartime. The helicopter's ability to respond quickly to resupply requests significantly reduces shipping times.

Having such support reduces uncertainty. The fact that the distribution system is practiced in peacetime should also give unit commanders some assurances that it will be able to support them in wartime.

There are no major problems with implementing this alternative. The resources are available within the 601 TCW; however, they would have to be reassigned to meet this particular mission. Maintainability of the alternative would not be affected, because the wing already plans to use a system similar to this in wartime; the difference is the system would now be formalized and dedicated.

Alternative 6. This alternative combines the actions of alternatives 3 and 5. Since the benefits of alternative 3 have been addressed at length, further discussion is not needed. The addition of alternative 5 under this alternative however, is slightly different. The distribution function would be organized and run as in alternative 5, but would only support the additional resupply points instead of the individual TACS units. This simplifies route planning to getting a few standardized routes precleared through NATO. NATO may support the concept of only a few routes, as in this alternative, rather than the many routes required to support alternative 5.

Collectively, the benefits of alternative 6 are tremendous. Improvements in all four criteria areas are realized. Responsiveness is improved since supplies will be located closer to the unit wartime operating location, and supply points are being kept restocked by a dedicated distribution system. Survivability is enhanced because there are now multiple resupply points for units to use. Uncertainty for unit commanders is reduced since they know where to get their supplies, and can get to them when needed. Finally, maintainability of the system by the 601 TCW is enhanced because the wing now has dedicated resources to support the resupply system, and has established preplanned routes to ensure the system remains in operation.

Problems that were addressed within alternatives 3 and 5 still exist, but are all within the abilities of the 601 TCW and USAFE to rectify, primarily through personnel reassignments and some restructuring of existing 601 TCW assets.

Phase 4 - Interpretation

Based on the discussions of the alternatives in phase 3, alternative 6 appears to be the "best" alternative to improve the performance of the TACS's resupply system. It provides significant enhancements in all four criteria areas, and would result in a more reliable, dependable resupply system to support individual TACS unit needs. Alternative 6 also meets the research objective of recommending a resupply system that is within the 601 TCW's capability to implement, given its existing resources.

Phase 5 - Verification

The potential performance enhancements that may be realized by the implementation of alternative 6 were estimated through the use of the Dyna-METRIC model. The model was used to compare spare parts resupply under alternative 6 to spare parts resupply under the existing 601 TCW resupply system, then determine if system performance improved under alternative 6. Spare parts were assumed to be representative of all types of supply items used by TACS units. Assuming it can be shown that implementation of alternative 6's resupply structure improves resupply system performance for spare parts, then it will be assumed that resupply system performance for all supply items used by TACS units is also improved.

IV. Dyna-METRIC Methodology

Overview

This chapter discusses how the Dyna-METRIC model was adapted for use with communications-electronics (CE) equipment, and applied to the mobile TACS. It begins with a literature review outlining the history and uses of Dyna-METRIC, discusses specific model assumptions and how they apply to mobile CE systems, relates the structural model design used to evaluate the TACS, presents model options and how they affected the final output, and ties all of these areas into specific scenarios for the TACS in Europe. The chapter ends with a discussion of validation and verification of the model.

History and Uses of Dyna-METRIC

In the last five years, researchers at the Rand Corporation have undertaken a series of projects designed to analyze aircraft readiness and supportability in a dynamic war. Steady-state models that were based on peacetime scenarios were found to be inadequate for realistic assessments of dynamic wartime scenarios (9:4). The search for appropriate dynamic models resulted in a series of dynamic queueing equations first used in 1978 by Berman, Lippiat, and Sims (9:iii). These equations, and techniques for their use, were modified and expanded to handle indentured repair and resupply capabilities. The resultant model which incorporated all the features was named Dyna-METRIC. The term METRIC was borrowed from Sherbrooke's 1968 model, and stands for Multi-Echelon Technique for Recoverable Item Control. The name Dyna-METRIC relates the time dependency aspect of the model in evaluating dynamic scenarios. Hillestad (1982) described the initial Dyna-METRIC model as it was formulated for use by the Air Force in developing the Combat Support Capability Management System (9:iii). The model could be used in two basic modes depending on the desired output; either a capability assessment mode, or a stock analysis mode. Air Force and Rand researchers began extensive experimentation using the initial model in a variety of scenarios which analyzed supportability of aircraft and jet engines at the wholesale (depot) and retail (base) levels.

For example, Clark (1981) used the model to assess the capability of a WRSK to support hypothetical tactical fighter squadrons. His presentation was primarily an illustrative example of the capability assessment features of Dyna-METRIC. He concluded that Dyna-METRIC was generally consistent with the D029 process used by AFLC to compute WRSK requirements (3:IV-93).

Pyles and Tripp (1983) described how Dyna-METRIC was imbedded into the management structure of the Ogden ALC, and used to assess quarterly spare parts requirements worldwide for the F-16 fighter. Their study pointed out the flexibility of the model in a large scale assessment role. They also stated the model was selected by the Air Force as the official capability assessment model for tactical aircraft applications (18:21).

The Tactical Air Command (TAC) has imbedded the model into their management systems to evaluate fighter aircraft support. At the base level, the TAC PACERS System (Peacetime Assessment of the Combat Effectiveness of Reparable Spares) uses the model to assess individual squadron capabilities. TAC uses a generic scenario for each MDS Primary Aircraft Authorization (PAA) size. Units initiate runs of the system from their wing command post. Their daily flying requirements are evaluated against WRM stock levels stored in the Combat Supplies Management System (CSMS). The evaluation is run on the World Wide Military Command and Control System (WWMCCS) at HQ TAC, and output is returned to the military unit. Output includes the potential number of sorties the wing could fly that day, a 30 day profile of potential NMCS aircraft, and a stratified report of parts causing NMC aircraft. The pacing item, that is the part causing the most NMCS aircraft, is listed first on the stratified report, and other parts are listed in descending order of their NMCS impact on the capability on the fleet. The system allows wing commanders to receive realistic daily assessments of their ability to support their flying program requirements (2).

AFLC uses the model to provide a macro assessment of theater wartime abilities as part of its Weapons System Management Information System (WSMIS). They have incorporated the model into the Sustainability Assessment Module of the Combat Logistics Assessment Subsystem (WSMIS/CLAS/SAM). The model provides weekly theater level assessments of three major warplans for tactical aircraft. Initially the capability of fighter aircraft to support the wartime plans was based solely on an evaluation of reparable spares. SAM now also addresses jet engines in the evaluation, and plans to have it evaluate consumable items are in work. However, Dyna-METRIC is used only to evaluate the reparable spares and engines. While the model currently evaluates just fighter aircraft, plans are also being made to include MAC and SAC aircraft in the assessment (2).

These four examples show how the model was adapted to analyze a variety of support postures for aircraft systems. These uses have led to changes in the basic model, and improvements in the model output. The changes were incorporated into two different versions. The following section examines the model functions and discusses the differences in the two model versions.

Model Versions and Functions

The version of Dyna-METRIC currently approved by the Air Force, version 3.04, was used in the examples mentioned above. The model views an airplane as a collection of spare parts waiting to fail. Failures require replacement, and if replacements are not available the aircraft is determined to be NMCS by the model. Version 3.04 considers two indenture levels, line replaceable units (LRU) which are essentially end items or carcasses composed of smaller parts called shop replaceable units (SRU).

The model functions can be described by a general scenario where two or more bases with identical Mission Design Series (MDS) aircraft are tied by resupply lines to support depots. The in-house repair capability at each base may be augmented by an intermediate repair facility (CIRF) which, in turn, is supported by the same depot as the bases. The depot is essentially outside the resupply system boundary, and considered by version 3.04 to be an endless source of supplies an OST value away (fig 6) (1).

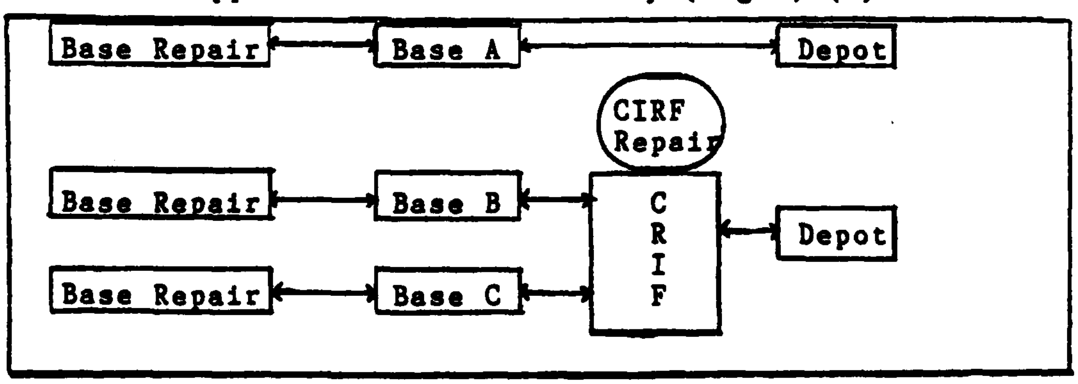

Figure 6. Dyna-METRIC View of the World (1:3)

The model uses a derivation of Palm's Theorem (16) to compute the daily level of each part in each pipeline shown in figure 6.

Hillestad and Carrillo (1980) modified the theorem to account for the time dependency of items in a queue, and developed a formula for a non-homogenous Poisson distribution that accounted for non-stationary demands and service times. By modifying the theorem, the model captures dynamic demands and transient behavior generally associated with variable flying hours and sortie surges. The daily values add a time dimension to the model not found in the earlier steady-state METRIC and base stockage models (10: section II).

In the mathematics of the model, a set of analytic equations is used to describe the dynamic behavior of the component repair queueing system. The equations center primarily on a probability function (figure 7A) which integrates variables such as failure rates, flying requirements, and quantity per aircraft (QPA) into a repair function (figure 7B) (9:9). Other variables are used to describe resupply pipelines and provide limits on the repair function, including OST values, transportation times, NRTS values, and repair cycle times. These values all work to produce an assessment of flying capabilities given a stockage policy, or to compute the optimal stockage needed to support a given flying program.

$d(t)$ = (failures per flying hour) X (flying hours/sortie at time t) X (number of sorties per day per aircraft at time t) X (number of aircraft at time t) X (quantity of the component on the aircraft) X (percentage of the aircraft with the component)

A. Probability Function

$$F(t,s) = \text{Prob}\begin{pmatrix}\text{Component entering repair at time s}\\ \text{is still in repair at time t}\end{pmatrix}$$

$$= \text{Prob}\begin{pmatrix}\text{Repair time} > \text{t - s when started}\\ \text{at time s}\end{pmatrix}$$

B. Repair Function

Figure 7. Repair and Probability Functions (9:9)

Rand modified version 3.04 to expand its capabilities. The modifications were incorporated into version 4.2 which was further updated and released as version 4.3. Wieland (1984) summarized the improvements to version 3.04 incorporated into version 4.3. The improvements significant to this thesis include:

(1) The depot can be described as more than an unlimited source of stock. Users can specify by part the depot repair time, repair capabilities, and various transportation times between the depot and the supported bases (24:2).

(2) The model results can be based on actual sorties flown and not just planned sorties as in version 3.04. This means the model can backorder only against what a unit could perform, and not what they planned to perform each day (24:3).

(3) Decisions to NRTS or condemn a part can be made before repair begins (24:3).

(4) There is more flexibility in entering parts data, such as demand rates, resupply availability, cannibalization abilities, and transportation times. In addition, multiple repair times and multiple QPAs per part per base can be assigned (24:3).

Because of these expanded capabilities, version 4.3 was used in this thesis.

Version 3.04 was a major program requiring a main frame computer system for data storage and operations. Units without access to a main frame computer were unable to use the model. However, in 1983 the Air Force Logistics Management Center (AFLMC) modified version 3.04 for use on the Cromemco microcomputer. Called miniature DynaMETRIC, or MINDM, the model provided limited capability assessments to analysts at the base and MAJCOM levels (8:1).

MINDM works only in the capability assessment mode, and bases its results on the following scenario limits:

(1) one base per run

(2) up to 1000 plus parts per run

(3) up to 90 aircraft per run

(4) up to 120 days per run.

Output includes operational information such as Fully Mission Capable (FMC) aircraft and expected FMC sorties per day; and parts information, such as expected on-hand quantities and backorders each day, and the locations of broken parts (8:2-3). MINDM has provided wing level planners a powerful tool to assess capabilities of tactical forces that deploy as autonomous squadrons during war. Recommendations for uses of MINDM with CE systems are discussed in chapter 6.

Dyna-METRIC was designed to evaluate aircraft support, and as seen from the above uses, has only been applied to tactical fighter forces. The model has not been used to evaluate CE system support because of perceived problems in equating fixed communication equipment operations to flying operations (13,14). Mobile CE equipment does not operate continuously 24 hours a day, 7 days a week. As a result parallels can be drawn between TACS ground radar operations and flying operations.

Purpose of Using Dyna-METRIC

Dyna- METRIC was used in this thesis to evaluate the effectiveness of the forward stockage and enhanced transportation capability proposal presented in chapter 3. Two basic scenarios were evaluated: 1) SAB supplying all support to the TACS units, augmented only by the limited satellite account at HOAS, and 2) SAB directly supplying two intermediate forward supply sites, which in-turn provide all necessary support to the TACS units. Because of some assumptions made in the scenarios, the model probably did not provide an exact assessment of TACS unit capabilities for each scenario. The limitations on the results and interpretations are found in chapter 5. However, the results provided were used to make a relative comparison of the two scenarios, and to determine if scenario two had more potential than scenario one to provide increased support to deployed TACS units. Increased supportability was determined by comparing the number of days each unit was at least Partially Mission Capable (PMC) in each scenario. The more days PMC or Fully Mission Capable (FMC), the better the support being provided.

Hillestad (1982) described the basic functions and mathematics of Dyna-METRIC, to include assumptions which were made within the model to simplify the math. An understanding of these assumptions, and how they relate to analysis of CE systems, is necessary before explaining the assumptions made in developing the scenarios for the TACS (9).

Analysis of Model Assumptions

A careful review of the Dyna-METRIC logic and assumptions was conducted to help determine if the model could be used to analyze CE equipment data. Seven key assumptions, drawn from Hillestad's (1982) description of the model, had the most impact on this determination. Pyles (1984) discussed some of these assumptions and their general impact on model output. His views are incorporated below as a basis for discussing the assumptions.

The first assumption states that component failure is time dependent, and directly proportional to the flying program and fleet size of any given base (9:47). Pyles states this assumption was made because no one has developed a mathematical technique to express component failure in terms of other variables; however, the subject is under continuing research (19:34). For CE equipment, the assumption is useful and accurate. Parts only fail on CE systems at the moment they are turned-on, while they are operating, and at the moment they are turned-off. After being shutdown, the electronic components do not fail, and there is no clear proof that components of CE systems fail less when the equipment operates for longer periods of time.

Mobile CE systems do not operate continuously, but instead are turned on and off as needed in between movements to different locations. Therefore, component failure of these systems can be directly linked to operating cycles and system size. The more equipment operates, and the more equipment there is in the system, then the more components there are that will fail while operating.

The second assumption, the repair and failure processes are independent (9:11), is made for simplification of the mathematics. Intuition suggests that the failure rate does influence the repair rate, and perhaps the quality of repair when there are large quantities of parts to repair, and a short time to repair them. However, the cross products of the two distributions are hard to achieve. The result of this assumption will more than likely be an overstatement of systems capability, or an understatement of the need for spare parts.

The third assumption indicates the number of failures occurring in any given time period is independent of the number occurring in a similar period, but centered on a different time (9:11). According to Pyles, this assumption was made as an attempt to hold down the amount of data needed to run the model (19:37). For mobile systems, this is probably a good assumption. However, there may be some dependency in failures occurring at the moment the system is turned on, particularly when the equipment is turned on and off several times during the course of a single day.

The fourth assumption deals with the component failure distribution, and describes it as a non-homogenous compound Poisson process (9:12-13). This distribution works out very well for mobile CE systems. Hillestad and Carrillo's modification of Palm's Theorem (16) adds quite a bit of flexibility to the failure process. Pyles states the Poisson distribution is "robust" in that one needs to deviate from the assumptions of the repair and failure processes substantially before exceeding the bounds of a Poisson distribution (19:27). In cases where the mean-time-between-failures (MTBF) does differ substantially from the exponential requirement of the Poisson, the model can be made to portray a binomial, or a negative binomial distribution, which can represent spacing or clustering of failures respectively.

The fifth assumption says cannibalization actions are instantaneous, and holes on the aircraft are minimized and consolidated to the smallest number of air frames. Hillestad says this cannibalization would actually only occur when needed, and the result of this assumption would likely be an overstatement of capability (9:30). Cannibalization of CE systems is uniquely different from that in aircraft systems. A CE system is composed of multiple subsystems, each having a separate Mission Design Series (MDS) number. An airplane is also composed of subsystems, but all are included as part of a single MDS. When "canning" in aircraft systems, the actions are between airplanes of the same MDS on a single base. However, canning from CE equipment may occur between different MDSs in the same system on the same base. This internal cannibalization cannot be modeled by Dyna-METRIC. Additionally, for the TACS, each unit is geographically isolated from others, thus precluding canning from other

MDSs outside the base. Users may need to assume cannibalization does not occur.

Assumption number six states that sub-components and their parent components fail independently. Hillestad concludes this assumption also overstates capability, and causes over cannibalization of the sub-components. He goes on to say though, that the assumption does lead to reasonable approximations since the rate of each subassembly failure is considerably smaller than the parent failure rates (9:46). His conclusion is probably accurate for CE systems.

The final assumption considered is probably the weakest in terms of CE systems; sufficient slack service capacity exists to avoid queueing in the repair of components. Hillestad reports this assumption to be valid as long as average demands remain less than 80% of the service capacity (9:77). Obviously this does not hold for surges. When modeling surges, users must identify the number of "work stations" available for maintenance. These stations can be test stands, personnel, work centers, or anything describing the limitation on how many parts can be repaired at one time. The model then uses a simulation process to analyze the service capacity and failures, and assigns repair to the work station based on a priority system. In the spares analysis mode, an analytical subroutine computes higher spare parts levels that can be maintained to overcome the surges, but only for a limited time period (9:79,81).

For mobile CE systems, this may not be a good assumption. Essentially a unit possessing a CE system also possesses all the base level capability to repair the system. Where they cannot repair it, the next higher level is depot. While on the move, supply pipelines are very unstable, and units do not have room to store more spares while deploying. As a result, this assumption may overestimate capability by repairing parts faster than reality, or overstate spare part requirements that units can realistically maintain to meet surges.

The assumptions of Dyna-METRIC just discussed appear to be valid when applied to mobile CE systems. Where the assumptions do not always apply, the result is usually an overstatement of capability; however, workarounds can be developed to adapt the model to the TACS. The next section discusses the specific scenario assumptions and workarounds used to model the TACS.

Scenario Assumptions

The following assumptions were made to meet the requirements of Dyna-METRIC, and to simplify the scenarios being evaluated. The first three assumptions are not related to the model itself, but were made in order to standardize the inputs for each unit and avoid excessively large data files. The remaining assumptions relate how the TACS data was worked to fit the requirements of Dyna-METRIC.

FACPs and CRPs did not substantially differ in this analysis. Each was considered as if it were a single aircraft which was composed of multiple components. Each unit needed a radar, SHF radios, UHF radios, secure radios, and power to declare themselves PMC. The declaration of mission capability was for the entire unit, and not for individual end items of equipment within the unit. The only differences between the two types of units were in the end items used to provide UHF and secure radio support.

Each end item of equipment in a TACS unit has its own WRSK. However, for this analysis all separate kits were treated as a single kit in each unit.

Actions occurring between SAB and AFLC depots would have been the same for all scenarios, and therefore were not modeled in any scenario. However, SAB was modeled as a depot without a repair function in all scenarios, because of its centralized supply mission.

For the TACS a "sortie" was defined as one hour of operating time, and the number of sorties per day was equal to the number of hours operated that day. Demands for spare parts were based on a flying schedule of 24 sorties per day per unit, unless the unit was deploying. Deploying units had a flying schedule of zero sorties per day.

Dyna-METRIC assumes failures are proportional to flying intensity and fleet size. For the TACS, users must assume failures occur only when operating, and more operating hours yield more failures.

Dyna-METRIC assumes repair and demand processes are independent. For the TACS this meant items were repaired in a unit on a first-in first-out basis, and without regard to the level of supply available. Units attempted to repair all parts before they were NRTSed or condemned.

Dyna-METRIC assumes NMCS figures in the output do not always mean a unit is completely non-mission capable, and in fact demands were generated against NMCS units. An analysis of the parts causing a NMCS unit was made external to the model to determine if the unit could have been instead PMC, and thus still able to support a mission.

Dyna-METRIC assumes a Poisson distribution for the failures, but allows for a binomial or negative binomial distribution based on the variance to mean ratio of the demands. For the TACS all failures were assumed to be Poisson because there was no data available to support the other distributions. In reality some failures were probably negative binomial because of the multiple application of the same parts on the different end items of equipment in the units. There was a potential for independent demands to be made at the same time for the same part during the independent repair processes of the separate end items of equipment.

Dyna-METRIC assumes there is sufficient slack service capacity in the units repair shops. The repair time for a part was assumed to be the same in all TACS units, but essentially only one echelon of repair existed in the model runs, and that was at unit level. Neither the depot, or any of the forward supply locations had a repair capability.

Cannibalization was not conducted in any of the scenarios. In reality the potential exists for lateral support between units (i.e., cannibalize at location A and ship to location B), or internal cannibalization within units. Dyna-METRIC could not model either of these cases. Therefore, with only a single "aircraft" assigned to each base, even cannibalization between units was not possible, and thus the results were assumed to be the same whether or not cannibalization was allowed.

These assumption were incorporated into a structural model designed to represent the TACS at war. The next sections review the structural model, and discuss how the model variables were manipulated to portray the TACS.

Structural Model Design

Figure 8 shows the structural model design, and the relationships between the variables and elements of the resupply system. The external variables are functions of

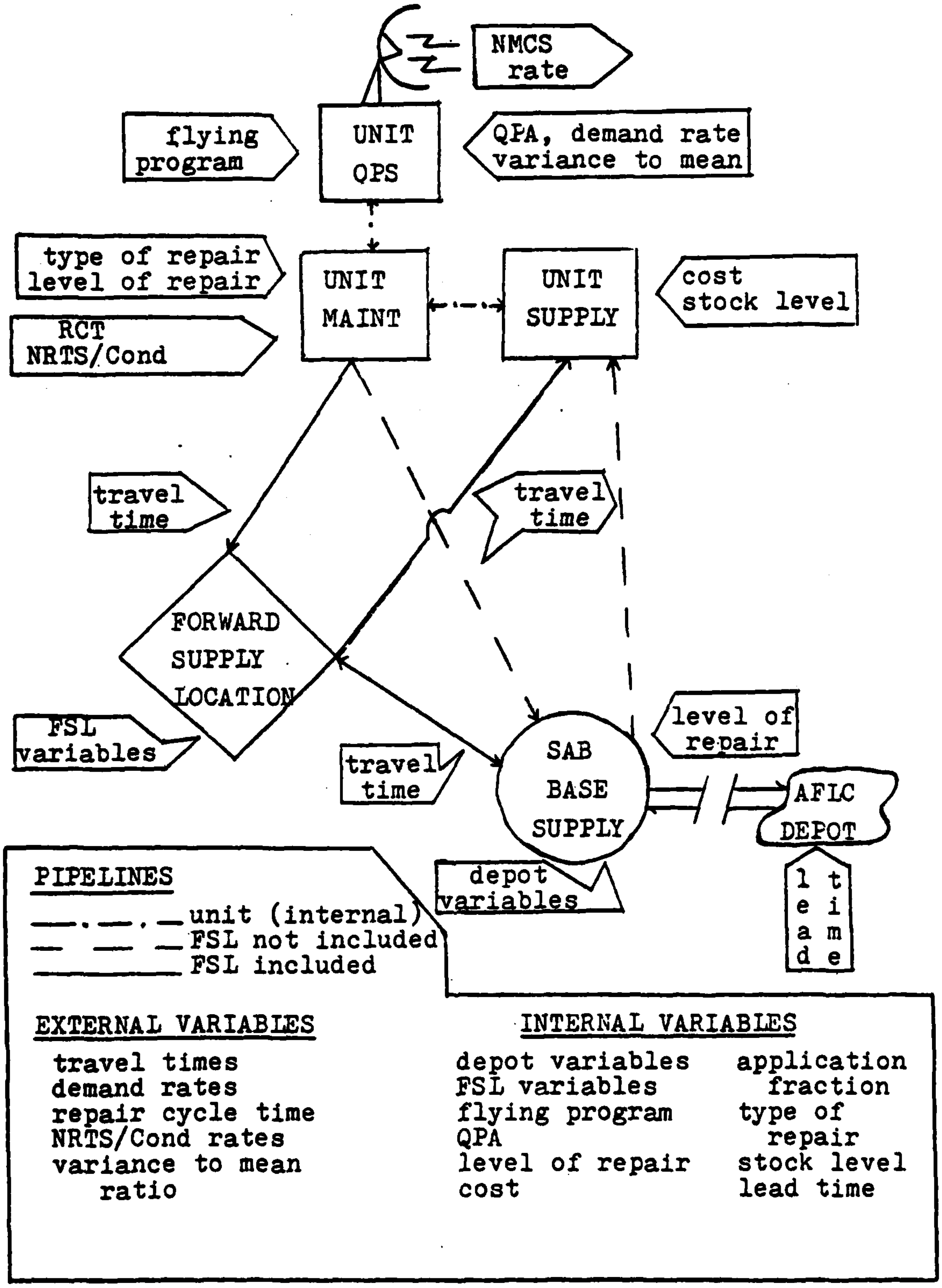

Figure 8. Structural Model Design

the system environment, and determined by the nature of the war. They are usually stochastic, and the elements within the system boundary cannot control or direct their values. However, the internal variables are directly affected by actions occurring within the system boundaries. These deterministic values are usually set by policy, warplan, or limitations within the system elements (such as repair capabilities).

The external variables act upon the unit, forward supply locations, base supply and the pipelines connecting them, resulting in a not mission capable rate at each unit, subject to the internal variables acting within the system elements. The criterion of a NMC rate was used to compare the two support scenarios discussed earlier (page 66). In figure 8, scenario one is represented by the pipeline from the unit to SAB; scenario two is represented by the pipeline from the unit to the forward supply location , and from the forward supply location to SAB.

In the next section, all variables used in the model will be defined and discussed as they applied to the TACS. The definitions and guidance on possible values were taken from the Dyna-METRIC version 4.3 input formats (12). Specific values for each variable are discussed with the variable definition.

Variables

General Variables That Apply to all Scenarios.

(1) Cutoff direction switch - Used to specify when the resupply pipelines are cutoff between the depots and bases either foward only, or both forward and retrograde. A value of one specifies both, and a value of zero specifies forward only. The pipelines were cutoff both ways in the first scenario for each region, and cutoff forward only in the second scenario.

(2) Exponential repair switch - Specifies whether transportation and repair delays have an exponential or a deterministic distribution. A value of one was used in all scenarios to indicate exponential distributions.

(3) Base administrative time - The deterministic delay (in days) experienced by LRUs removed from the equipment prior to entering unit repair. One half day was used in all scenarios.

Depot Variables (base supply at Sembach AB).

(1) Resupply start - The time at which resupply from industry first becomes available at the depot. A value of 180 days was used in all scenarios.

(2) Resupply Availability - Indicate whether the peacetime resupply pipelines from the depot continue to empty prior to the time industry resupply is available to the depot. A value of one was used in all scenarios to indicate the pipelines do continue to empty.

(3) RR/RRR repair start - This is the day on which the depot can begin to repair LRUs coded RR (remove and replace) and RRR (remove, repair, and replace) that were NRTSed to the depot from the units. This value was day 180 in all scenarios to reflect that SAB had no repair capability. Broken parts sent to SAB were not repaired during the time span of the scenario modeled.

(4) SRU cannibalization switch - A value of zero was used to indicate depots could not cannibalize.

Forward Supply Location Variables. (CIRF)

(1) Resupply Availability - A value of one was used in scenarios having a forward supply location to indicate industry pipelines to that location continued to empty, before the wartime pipelines could be established.

(2) SRU cannibalization switch - A value of one was used to indicate the forward supply location could not cannibalize even though the location had no repair capability. Using this variable ensured cannibalization would not occur.

Base Variables. (applicable to each TACS unit)

(1) Transportation time - This is the travel time in days between a unit and its supporting forward supply location. Values used will be explained under experimental design.

(2) Forward supply point start - The day on which resupply from the forward supply location first becomes available to the units.

(3) Forward supply location availability - This is used to indicate whether peacetime pipelines between the units and the forward supply location continued to empty prior to the time wartime resupply from the forward supply location first became available.

(4) Resupply cutoff - The day on which pipelines between a unit and its forward supply location were cutoff due to the unit redeploying to a new location.

(5) Cutoff duration - The number of days it took the unit to redeploy, and then reestablish the pipelines between itself and its supporting forward supply location.

(6) Repair start - The day on which the units could begin to repair RR and RRR spares. These values were day one in all scenarios, because the units deployed with all of their maintenance capability in all scenarios.

(7) SRU cannibalization switch - a value of zero was assigned to indicate the units could not cannibalize.

(8) Sustained Demand Start - A value of zero was assigned to indicate that the wartime demand rate was used throughout the entire run. The LRU Variables section explains how the demand rates were computed.

(9) Reparable arrival time - The day on which peacetime reparables were deployed to the unit. This was day one

in all scenarios, because the units deployed with their WRSK, and all repairable spares regardless of their condition.

<u>Transportation</u> <u>Variables</u>.

(1) Transportation times - these are the travel time in days between the units and SAB, and between the forward supply locations and SAB.

(2) Transportation availability - Indicates whether the peacetime pipelines from SAB to the forward supply locations/units continued to empty prior to the time transportation to the sites was available. A value of zero was used in all scenarios to indicate the pipelines did not empty until transportation from SAB was available.

(3) Transportation start - Day on which transportation from the depot first became available to the unit/forward supply location. In all scenarios, transportation to the forward supply locations from SAB was available on day one, however, transportation to the units was not available until day three. In reality, the units would not be stabilized and able to receive spares from SAB until at least three days after they deployed from their garrisson locations.

(4) Transportation cutoff - The day that transportation from SAB to a unit was cutoff because the unit was deploying to a new location. This day coincided with the resupply cutoff values on the base (unit) cards, and the depot card.

(5) Cutoff Duration - The number of days required for the unit to move and reestablish contact with SAB. This value also corresponded to the duration values on the depot and base cards.

Flying Program Variables.

(1) Aircraft - this is the number of "airplanes" assigned to each TACS unit. The value was always one as explained earlier under assumptions.

(2) Sorties - This was the number of hours each unit was required to be operational each day in each scenario. This value was set at 24 when the units were operating, and at zero when the units were deploying.

(3) Flying Hours - This value determines the length of each sortie scheduled for the unit. It was set at one hour in all scenarios to correspond with the 24 hours of required operational time set by the "Sorties" value. The combination of Sorties and Flying Hours reflected each unit was required to "fly" 24 one hour long sorties every day they were not redeploying to a new location.

(4) Attrition - This value reflected the number of aircraft attrited per sortie at each base on each day of the war. It was always set to zero, because their was no data to justify attrition of TACS units during a wartime scenario. It was assumed all units survived the first 27 days of the war modeled in each scenario.

(5) Turn rate - This value is the maximum number of hours each mission capable unit could generate per day during the war. It was always set to 24.

LRU Variables. (Note: only LRUs were modeled in this analysis. The available data did not reflect indenture relationships between the parts listed below, so all were assumed to be LRUs).

(1) LRU name - The National Stock Number for the part as recorded in the Univac 1050-II at SAB base supply.

(2) Level of repair - This value was always set to one to reflect a part could be repaired at base, CIRF, or depot level. However, later variables were used to show the depot and forward supply location had no repair capability.

(3) CIRF Repairability - This value was set to zero in all scenarios to reflect the forward supply location had no repair capability for any of the parts modeled.

(4) Quantity per aircraft - This is the number of LRUs in all of the end items of equipment in each unit. For example, if their were two of a particular stock number in the radar, and one in the HF radio van, then the QPA would be three for the unit.

(5) Minimum QPA - The minimum number of this part on the unit equipment that must be working for the equipment to be at least PMC by NATO standards. The entire QPA was required for the equipment to be FMC. If less than the QPA amount was working, then the unit was subjectively

determined to be PMC for that piece of equipment by the authors. When less than the minimum QPA amount was working, then Dyna-METRIC reported the unit as being NMCS for that item.

(6) NRTS/Condemn Indicator - This value was zero in all scenarios, indicating parts entered repair at all units before they were NRTSed or condemned.

(7) Demand Rate - This was the number of demands per operating hour experienced by each part. Values were computed using the steps shown in figure 9. Data on the number of demands in step one was provided by the 601 supply squadron. The number of operational hours in step two were subjective determinations based on the assumptions an average operating day was 8 hours for the TACS unit, and the average number of units operational each day was 12 of 15.

(8) Unit Repair Cycle Times/NRTS Rates/Condemn Rates - These values were provided by the 601 supply squadron, and were the values for each part stored in the item records of the UNIVAC 1950-II computer at SAB. RCT is the average number of days a part was in base repair, and the NRTS rate was the percent of all items entering repair that were not repaired at the base level. The condemn rates were the number of all parts entering repair that were condemned at the unit and neither repaired or NRTSd. The values used were the same for all bases whether or not they were served by a forward operating stock location.

AD-A147 286 A DYNA-METRIC ANALYSIS OF SUPPLY SUPPORT FOR MOBILE TACTICAL RADAR UNITS I..(U) AIR FORCE INST OF TECH WRIGHT-PATTERSON AFB OH SCHOOL OF SYST.. 2/2

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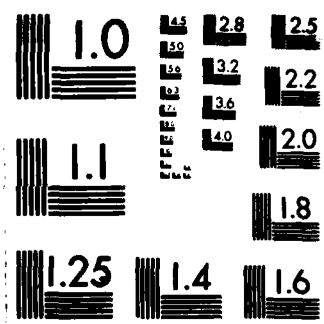

MICROCOPY RESOLUTION TEST CHART
NATIONAL BUREAU OF STANDARDS-1963-A

STEPS	EXPLANATION
1.	Determined the number of demands per part in the last 440 days (five quarters) from item record information provided by the 601 Supply Squadron (batch inquiry on all WRSK NSNs).
2.	Determined the total number of operating hours during which the above demands were generated. Subjective, based on: 440 days - down days (weekends and holidays) X average number of ops hours per unit per day (8 hours) X average number of units ops each day (12 units) = total ops hours
3.	Computed the meantime between demands (MTBD) for each part:
4.	Computed the demands per flying hour (ops hour) for each part:

$$\text{MTBD} = \frac{\text{total ops hours (step 2)} \times \text{quantity per end item of the part (QPA)}}{\text{total demands for the part (step 1)}}$$

$$\text{D/FH} = \frac{1}{\text{MTBD}} .$$

Figure 9. Computing the Demands per Ops Hour

(9) Depot Repair Time - The RCT for a part entering depot repair. This value was 180 days in all scenarios, to reflect the lack of a repair capability at SAB.

(10) Depot Repair Limit - The maximum number of parts a depot could repair each day. SAB had no repair capability, but reparable parts had to pass through there on their way to the AFLC repair facilities in the CONUS. A value of 99.0 was used for this variable in all scenarios to reflect the fact there was no limit placed on the number of reparables that could be sent through SAB for future repair.

(11) Peacetime/Wartime Repair Times - These values were the production lead times for depots to procure replacement spares for forwarding to the TACS. 180 days were used for both values to reflect the lead time did not occur in the first 30 days of a war.

(12) Cost - The actual cost of each item as stored in it's item record at SAB.

(13) Cannibalization Indicator - A value of one was used on all parts to indicate they could not be canned.

(14) Application Fraction - Percent of the unit "aircraft" possessing this item. If the part was on a piece of equipment in the unit, the application fraction was 1.0; if not, it was 0.0. For example, the TSC-53 van was a FACP item only, so the application fraction for CRPs for the parts in the TSC-53 were all 0.0.

(15) Maintenance Type - All parts modeled were coded RRR items under the assumption each unit possessed the capability to repair the majority of their WRSK items, and attempted to repair every broken part.

(16) Demand Rate Multiplier - A number entered in this field was multiplied times the demand rate, to reflect a potentially higher wartime rate. However, a value of 1.0 was used in all scenarios because the failures of parts during an hour of operations did not differ between peacetime and wartime. Units operated more hours during wartime, which caused more parts to fail, but their MTBF did not change.

(17) Variance to Mean Ratio - This was the ratio of the failure distribution variance to it's mean. A value of 1.0 was used in all scenarios to indicate the failures were Poisson.

(18) Stock Level - This was the number of each part in the WRSK of each unit, and also on the shelf at SAB and the forward supply locations. The values were taken from the information provided by the 601 supply squadron for each part modeled.

Model Options

The type of analysis desired by Dyna-METRIC (capability assessment or stockage assessment) was determined by various options which the user could specify in the input files.

The options used in the modeling of the TACS, with a brief definition, are displayed in table 1.

TABLE I

DYNA-METRIC OPTIONS

OPTION	MEANING
8	List Problem LRUs, Up to 70 LRUs maximum.
10	Use provided pipelines, rather than default.
11	Calculate performance at 0% NMCS based on input or previous stock. 80% confidence interval was requested.
13	Do not echo scenario inputs.
14	Do not echo parts input.
15	Generate detailed pipeline/backorder file.
16	At the last time of analysis, write out pipeline values to be used to restart the model. (Note: The saved values will be used as provided pipelines under option 10.)

Option 8 caused a problem LRU list to print out after each daily status report. LRUs only appeared on the list when they had greater than a 20% chance of causing an NMCS unit.

Option 11 caused the daily capability assessment report to print out. Values in the reports were computed based on a desired number of NMC aircraft being equal to zero each day, within an 80% confidence interval.

Options 13 and 14 suppressed the echo of input data, and were used on the second and third files of a full series to save paper and avoid duplicating data already printed out in prior runs. Option 15 produced a pipeline report that was used to determine the number of parts in resupply pipelines each day. The daily pipelines for each scenario were compared to see if there was an improvement (less stock in the pipeline) due to prepositioning at forward supply locations.

Options 10 and 16 worked together to produce what Pyles (1982) referred to as bootstrapping (19:24-25). The first file of a three file series was run with option 16 to save its results in a "save" file. The second file, run with options 10 and 16, used the file one "save" file as a starting point, then saved its results in a second "save" file. The last file used only option 10, and started with the saved data from file 2, but did not save its own results in a third "save" file.

Model Limitations

Even with the workarounds to the scenario assumptions, the input variable values, and the model options, Dyna-METRIC could not wholly model all aspects of the mobile TACS resupply system. Each of the following limitations was not completely resolved in the scenarios, and represents a deviation from reality. The discussion includes a description of each limitation, and its impact on the model outcome.

Transportation time between elements in the resupply system is deterministic in the model logic, but is actually stochastic in daily TACS operations. This variability in transportation times is caused by the continual redeployment of TACS units. A limited workaround to this limitation involved making changes in the values between model runs, then "bootstrapping" successive runs together to achieve the desired impact (18). However, this was not a real solution because only best and worst transportation time values were used for each scenario, and not a complete distribution of random variables.

Cannibalization could not be conducted between pieces of equipment in the same unit, or between identical units. No workaround was used to resolve this limitation, and the result was probably an understatement of unit capabilities.

The model could only evaluate a single MDS at each base; however, TACS units are composed of multiple pieces of equipment, each having a separate MDS (TPS-43E radar, TRC-87 radio van). A partial workaround to this limitation was achieved by treating the unit as a single aircraft on a base, and determining the status of the unit based on the status of each piece of equipment. Equipment status was determined by evaluating the problem parts list and making a subjective determination of unit status each day.

External variables having a significant impact on TACS performance, such as unit manning, additional commitments, supply sources outside Air Force channels, and the wear and tear on parts due to deployments could not be represented in the model. Some of these variables were subjectively included in other values, such as administrative times and transportation times, but most were ignored in the scenarios. The result was probably an overstatement of unit repair capabilities causing an understatement of resupply requirements.

Procedure

The structural design, assumptions, and limitations presented earlier were all used as a basis to "construct" two basic scenarios to model the TACS. The units were divided into two regions according to the NATO ATAF they would operate in during a war, then each scenario was run separately in each region. The file structure used in each scenario is shown in figures 13 and 14, and will be discussed in the experimental design section.

In the Northern region, scenario one described the current resupply structure (Figure 10A). In this run SAB provided supplies to their satellite account at HOAS, who in-turn issued them to the units on demand. If HOAS did not have the item, units placed a demand on SAB for the part. When units deployed, all pipelines stopped between HOAS/SAB and the units, but the pipeline between SAB and HOAS remained open. Neither SAB or HOAS had a repair capability. All base level maintenance was done at the unit, and if the

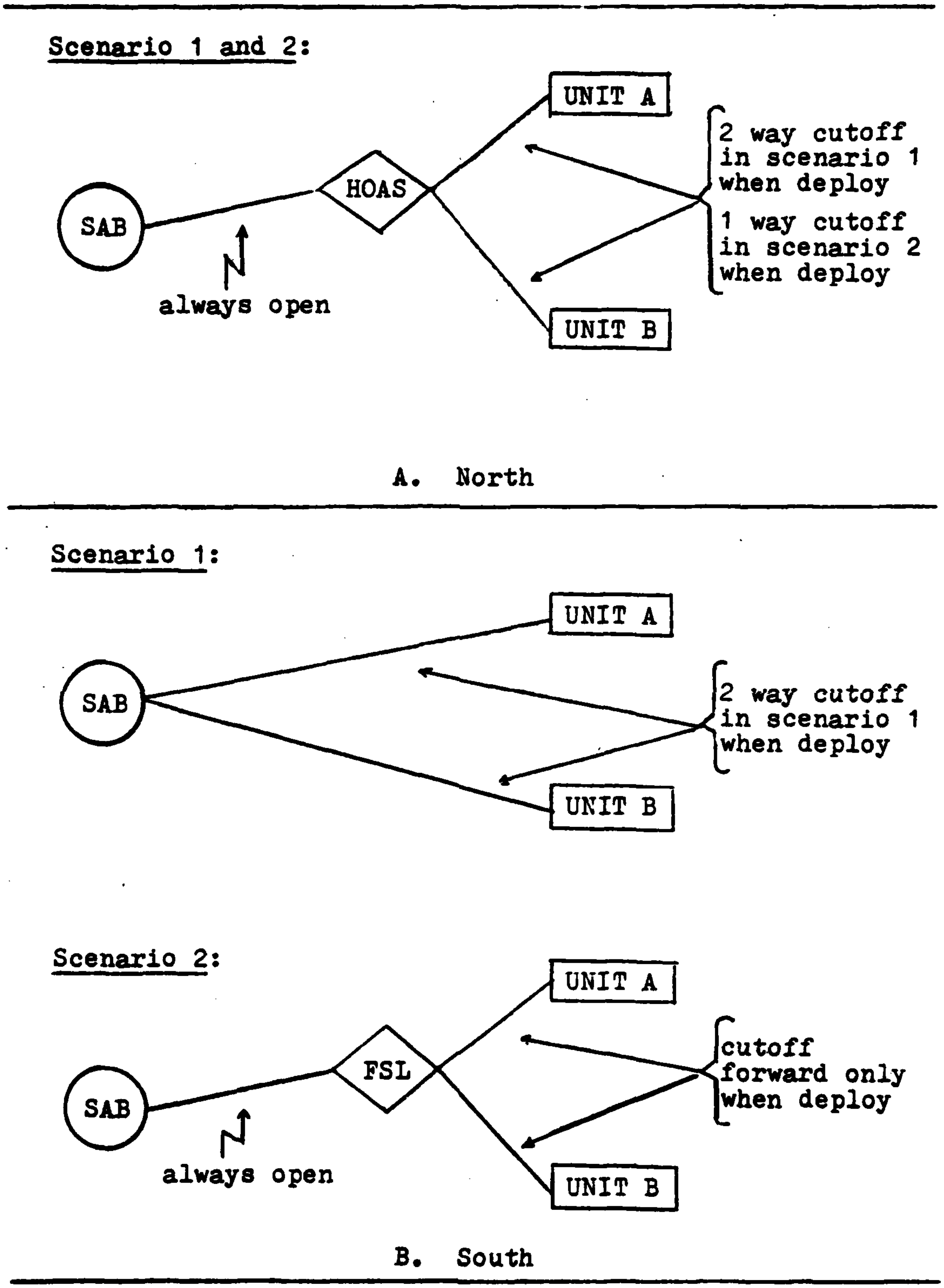

Figure 10. Pipelines in Each Scenario

part was NRTSed it went first to HOAS, then SAB for further relay to an AFLC depot in the CONUS.

In scenario two for the Northern region, all things remained the same as in scenario one, except the retrograde pipelines between HOAS and the units were never cutoff. This implied units were responsible for the transportation link between themselves and their supply source. This allowed commanders the flexibility to pick-up parts from HOAS, and deliver NRTSed items whenever they wanted to, and thus did not have to wait for transportation to be available from HOAS before they received or returned parts.

In both scenarios, AFLC depots did not provide support before day 180, and SAB was modeled as a supply depot only. Each CRP moved once in 30 days, and each FACP moved twice. The movements and transportation times were identical in both runs. However, a distribution of times was not used to select the transportation times between elements. Instead, each scenario was run with a best estimated transportation time between locations, then rerun with a worst possible time. The actual values would have been somewhere in between, and the resultant NMC rates would vary with the times.

Scenarios for the Southern region differed from the North because there was no peacetime satellite account in 4 ATAF to augment SAB like HOAS did in the North. In scenario one (Fig 10B) SAB provided all support directly to 9 units. When the units deployed, their support pipelines were cutoff until the unit was operational at the new site. SAB had no repair capability, and maintained only a limited stock of WRM spares.

In scenario two a forward supply stock was placed in Southern Germany to provide spare part support. SAB supplied the forward stock, and units drew from the stock as needed. As in scenario two for the north, no pipelines were cutoff, because the unit was responsible for transportation. In both Southern scenarios, SAB acted only as a supply depot (no maintenance) and AFLC depots provided no support. Transportation times between elements were the best and worst estimates again as in the north.

The differences between scenarios one and two in each region were selected in an attempt to determine the impact of variable transportation times, and unstable pipelines between elements in the resupply system. By decreasing the variability in transportation times (i.e., adding a forward stock in the south) and by opening the pipelines even while deploying, commanders were given a more stable resupply system to depend upon. This more stable system had the potential to remove the uncertainty commanders experienced when they had to depend on a single source of supply, possibly two days away, to deliver parts that they requisitioned.

Output Formats and Interpretation

Results from each scenario run were recorded in the format shown in figure 11. The goal was to determine which scenario provided for the best support to the units by analyzing the NMC status for each unit on each day of the scenario runs. How the runs were structured to obtain the results will be discussed in the experimental design section. The specific model output needs to be dicussed at this point to help understand how the results were obtained.

TABLE X

SAMPLE OF RESULTS TABULATION

RUN	UNIT	DAY 1	2	3	4	27
	601C					
	602C					
	603C					
	612F					
	621F					
	631F					
	632F					
	611F					
	622F					
Backorders						
		file 1		file 2		file 3

F = FMC   P = PMC   N = NMCS   D = DEPLOY

Figure 11. Scenario Results (sample)

For capability assessment, the model prints out a table, as shown in the daily report sample in figure 12, for each reporting period requested by the user (i.e., daily, every five days, weekly). Because the TACS units have only one "airplane" per base, the full cannibalization and partial cannibalization results should be the same for each base.

"Target NMCS" is the allowable number of NMCS aircraft for that day on each base as specified by the user in the input files. A value of zero aircraft was used for all TACS scenarios because there was only one aircraft on each base. "Prob 0% NMCS" is the probability of having the target number of aircraft or less NMC that day. "Prob Achieve Sorties" is the probability of being able to fly all the sorties scheduled for that day. For the TACS this is the probability of being able to operate all the hours scheduled for that day. "FMC - 80% Conf" shows the number of aircraft assigned to each base which are able to fly the sorties scheduled for that day. This value was computed using an 80% confidence interval, which means the unit was FMC as long as the "Prob 0% NMCS" was greater than .80. "E(NMCS)" is the expected number of NMCS aircraft in each unit that day, and should equal the total number of aircraft assigned minus the number FMC. "E(Sorties)" is the expected number of scheduled sorties that could be flown that day with the number of FMC aircraft available. For the TACS, this value is the number of scheduled operating hours that could be achieved that day.

Daily Report

PERFORMANCE BASED ON STOCK ON HAND ON DAY XX.

--------FULL CANNIBALIZATION--------

		PROB	PROB	FMC-			TOTAL
	TARG.	0%	ACHIEVE	80.%			BACK
BASE	NMCS	NMCS	SORTIES	CONF	E(NMCS)	E(SORTIES)	ORDERS
606C							
609C							
626F							
636F							
619F							
629F							
TOTAL							

Note: Full cannibalization and partial cannibalization results were always the same.

Problem IRUs

DETAILED PROBLEM PART PIPELINE SEGMENT REPORT AT BASE AAA ON DAY XX--

NAME	NUMBER	ADMIN.	INTEST	AWP	ORDERED	TOTAL	STOCK	BACKORDERS
NSN	L 10	0.00	0.00	0.	0.	0.00	1	0.00

Note: Only problem IRUs will appear on this report.

Pipeline Report

DETAILED PIPELINE SEGMENT REPORT AT BASE AAA ON DAY XX--

NAME	NUMBER	ADMIN.	INTEST	AWP	ORDERED	TOTAL	STOCK	BACKORDERS
NSN	L 1 to L 70	0.00	0.00	0.	0.	0.00	1	0.00

Note: All IRUs will appear in this report for each base on each day reported.

Figure 12. Samples of Model Output

These values were all used to determine the mission capable status of each unit for each day reported, which was the criterion variable sought in the structural model design (figure 8). The lower the probability of being 0.0% NMCS, then the lower the probability there was of achieving all scheduled operating hours during the day. These two numbers drove down the number of FMC aircraft; however, with only one aircraft, this value was always between zero and one. A value of less than one FMC aircraft was interpreted to be the probability of having the unit FMC that day. For example, a value of .72 meant there was a 72% chance of the unit being FMC that day. With less than one FMC aircraft, the corresponding E(NMCS) increased and the E(Sorties) decreased.

The "Prob 0% NMCS" was used in conjunction with a problem LRUs listing (figure 12) printed out following the daily report to determine the oveall unit status for each day of each scenario period. Whenever the "Probable 0% NMCS" was less than .50, the number of FMC aircraft was less than .5, or the E(Sorties) was less than 8.00, then the unit was truly NMC as computed by the model. These cutoff values were subjective points chosen by the authors, and correspond with the amount of equipment needed, or the minimum number of hours able to operate and still support a NATO commitment. If these values were between .80 and .51 for the "Prob 0% NMCS", or between .80 and .51 FMC aircraft, or between 8.01 and 22.0 for E(Sorties), then the unit was determined to be PMC by the authors even though the model would report it as NMC. These values ensured the unit had operable equipment to support NATO, without all end items needing to be FMC. When the "Prob 0% NMCS" was greater than .8, or the number of FMC aircraft equaled 1.0, or the E(Sorties) was greater than 22.0, then the unit was computed as FMC by the model, and considered FMC by the authors.

However, the daily report could have shown an FMC status, but in fact the unit may have been only PMC because of problem parts causing individual pieces of equipment to be NMCS. The status of the equipment end items was determined by evaluating the problem LRU listing. If the number of demands for a part exceeded the number of that part available, or in stock, then the model generated a backorder for the part, which left a "hole" in the piece of equipment. An individual piece of equipment may have been NMCS, but due to redundancy of equipment, the unit may still have been able to operate for all scheduled hours. So, by NATO standards, the unit was not FMC, but was actually PMC. When the number of holes in all like items of equipment fell below the minimum QPA for that part, the result was a complete loss of the redundancy, and the unit became NMC. For example, if a CRP lost its single radar, then it was NMC. However, if it lost one of its three TRC-87 UHF radio vans, it was PMC. It would only become MNC when it lost all three TRC-87 vans.

The final diagnostic table used was a pipeline report (figure 12). This report showed the number of backorders for each NSN at each unit at the end of the reporting period. The pipeline report was used to evaluate changes in the pipelines between different scenarios, and determined if there were improvements in the pipelines between scenarios.

The next section discusses the specific format of each input data file, the structure of each model run, and the method used to tabulate the results.

Experimental Design

Two primary objectives were sought with the Dyna-METRIC model in the modeling process. Each objective will be discussed, along with the modeling scheme used to achieve them.

The first objective was to determine if DynaMETRIC could be used to model CE systems. This objective was met through a verification process in a small scale version of the first scenario described for each region.

Using Version 3.04, two files were constructed from data generated by four TACS units during REFORGER 1983 (September 1983) on 17 WRSK stock numbers. The four units were treated as a single region, each directly supported by SAB only in the first 30 day run, and by SAB and a forward supply point in the second run. The demand data used was based on demands placed for the spares just during the REFORGER period, and not the more accurate demand data stored in the item records for the stock numbers in base supply.

Version 3.04 was used in the initial verification process, because it has been verified and validated with respect to producing reasonable rsults for scenarios involving fighter aircraft. The validation process occurred during a Red Flag exercise at Nellis AFB, Nevada in 1982 called "Leading Edge". Data collected from the exercise on the flying program and maintenance/supply actions was fed into the model. The model then replicated what actually occurred during the live flying exercise (2).

In a similar fashion, data generated by TACS units during the REFORGER exercise was fed into the model. The results of the runs using the TACS data were used to verify if the validated version 3.04 also produced reasonable results for CE system scenarios.

After the runs were made in 3.04, the files were converted into version 4.3 formats, and two more 30 day runs were made. The results of the 4.3 runs were compared to those from the 3.04 runs to see if they were the same. By this method, the results obtained from the validated version 3.04 could be used to determine if version 4.3 was producing correct results from the input data.

The second objective, an analysis of the TACS to substantiate prepositioning as a viable concept, was met by building data files in version 4.3 and structuring the variables to describe the scenarios discussed in the Procedure section of this chapter. The demand values were provided by SAB from data stored in the item records for 70 stock numbers used in each unit WRSK (i.e., repair cycle time, NRTS rates, condemn rates). Three files were used in each run, each being identical except for changes made in transportation times between elements of the resupply system and cutoff switch values. The three files were necessary to show unit moves. Only one transportation time per unit between any of the other elements could be assigned in a single run of the model. By using bootstrapped files, a unit could be moved in each file, and the new transportation times could be used for the computations for that file. The pipelines between elements were not destroyed at the end of each file, so a continuous scenario could be run using three separate files, with each file starting where the file that preceded it ended. Each file actually represented a single run of the model, but the term "run" was used to reflect three files being run in succession and tied together by options 10 and 16.

In the Northern Region (figure 13), run one was the baseline of the current peacetime system, using best estimates of transportation times between elements. Run two

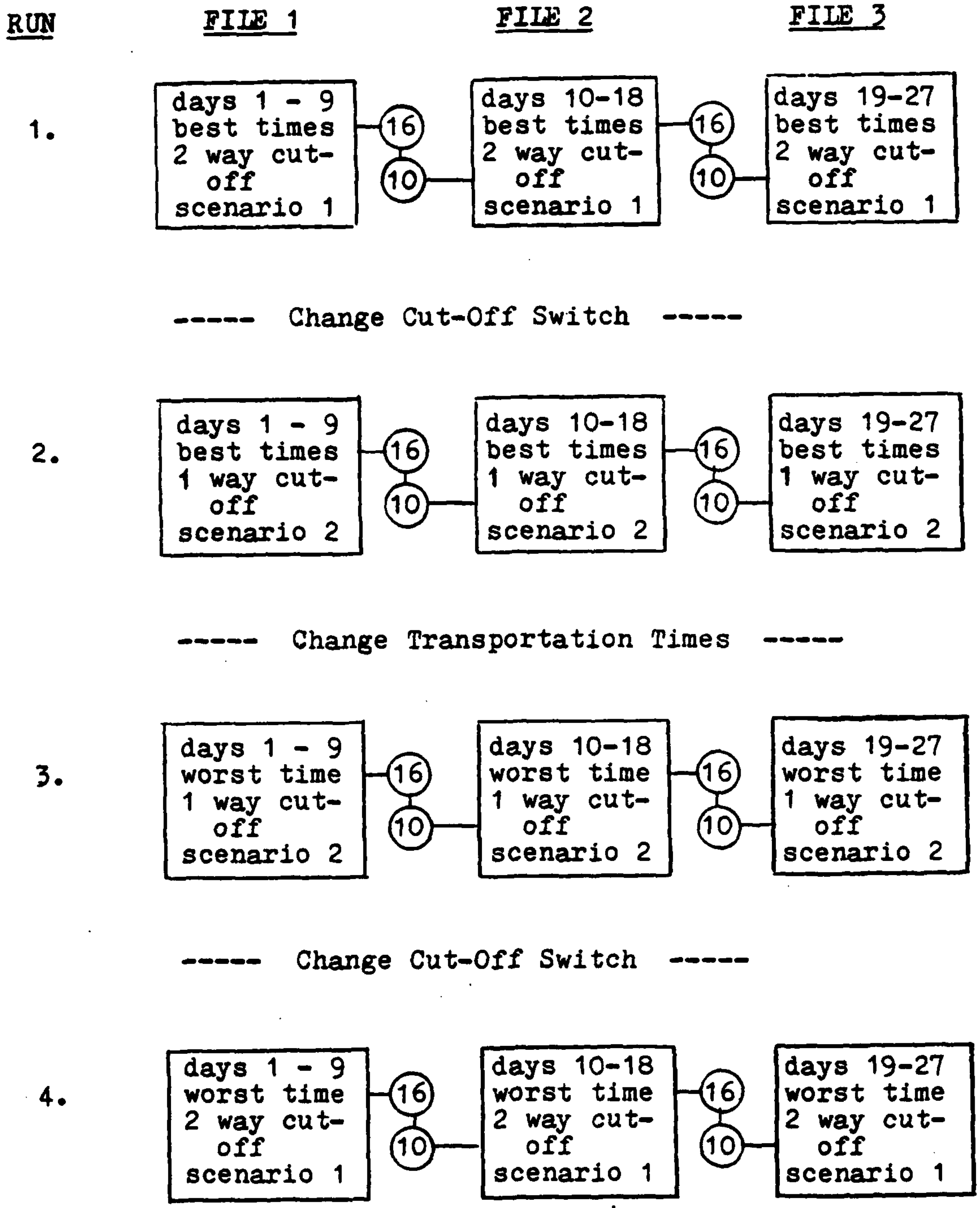

Figure 13. File Structure for Northern Region

was a proposed wartime change where pipelines were not cutoff and transportation was always available from the unit. Runs three and four repeated runs two and one respectively, but used worst case transportation times instead of the best case. The values used in each file are presented in Appendix A.

In the Southern region (figure 14), run one was the baseline for the current peacetime system. Run two modeled the proposed wartime system with the proposed forward supply point, and open pipelines achieved by using unit vehicles to provide all necessary transportation. Runs three and four repeated runs one and two respectively, only they used worst case transportation times.

The NMC status for each unit, on each day of the 27 day run was recorded on a table as in figure 11. The unit results were then used to determine a daily regional status for the TACS. If more than 50% of the units in any region were NMC on any day, the region could not support a NATO commitment that day. This decision point was selected by the authors, and assumed the region lacked the appropriate overlapping radar coverage, and communications links necessary to effectively manage the air war when greater than 50% of the units were NMC. The specific numerical results are discussed in chapter 5.

A secondary objective, a capability assessment of the current WRSK used in the TACS, was partially achieved in

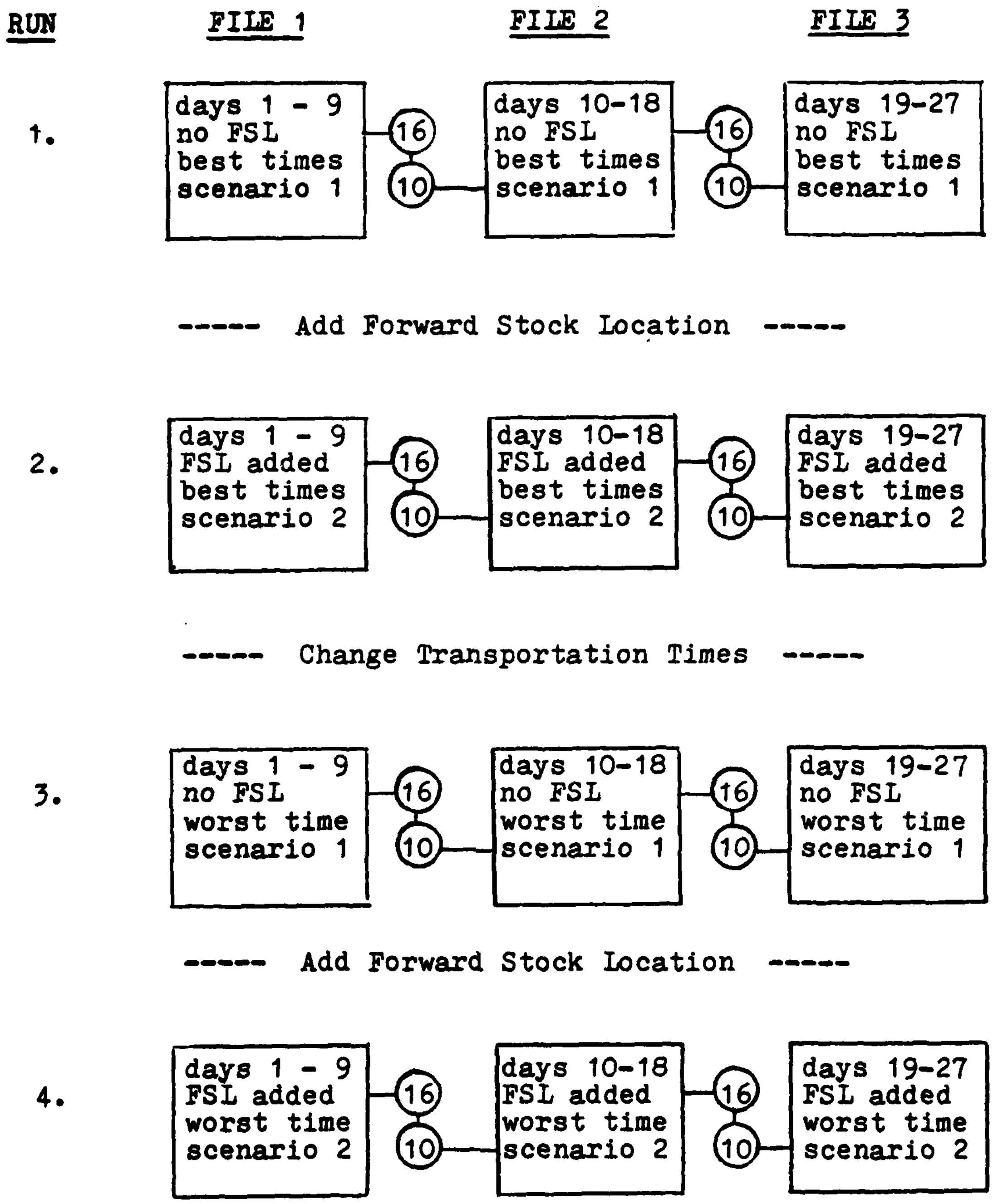

Figure 14. File Structure for Southern Region

the running of the model, because only WRSK NSNs were evaluated. Seventy NSNs, which represented approximately eight percent of the total parts available in the kits, were randomly selected for analysis in the model from the data provided by the 601 supply squadron. The NSNs were selected from the following WRSK kits for each type of TACS unit:

CRP	FACP
TPS43E (Radar)	TPS43E (Radar)
TRC97A (SHF Radio)	TRC97A (SHF Radio)
TRC87 (UHF Radio)	EMU30 (Power)
TGC28 (Secure Comm)	TSC53 (UHF/HF/Secure Comm)
TSC60 (HF Radio)	
EMU30 (Power)	

This may not be a completely accurate assesment of WRSK capabilities, because the model assumed no cannibalization capabilities, and all parts were RRR, and only a small number of WRSK items were evaluated. Recommendations to obtain more accurate assessmnets are discussed in Chapter 6.

Model Validation

Version 3.04 has been shown to produce valid results for fighter aircraft scenarios, as discussed in the Experimental Design section. By extension, results of the version 4.3 model runs, with TACS data from REFORGER 1983, may show that version 4.3 is a valid model if it replicates the results from version 3.04 runs of the REFORGER data. Results are contained in Chapter 5. This process only verifies and validates the internal logic and processes of version 4.3, excluding the capabilities of version 4.3 that could not be used in version 3.04.

An external validation of version 4.3 was beyond the scope of this thesis. Such a validation would require a large scale, live exercise to generate data that could be used to validate the model. In addition several options and features of version 4.3 were used in the analysis of the TACS, that were not used in the verification process with the REFORGER data (i.e., modeling SAB as a depot, using options 10 and 16 to bootstrap model runs and inputting a minimum QPA for each part to determine the FMC/NMC cutoff). These features were not validated.

Summary

DynaMETRIC has been used in several applications to analyze aircraft systems. No attempts have been made to apply it to CE systems, because it was felt that the assumption of the model did not apply. An analysis of the assumptions led to a conclusion that the majority did apply, and where they did not, the results were usually and overstatement of system capability (i.e., the results generated were the best that could occur).

However, workarounds to the model's assumptions and limitations can be employed, and the model can be fit to scenarios for mobile CE systems. For the mobile TACS, these workarounds include bootstrapping successive runs to model unit movements, modeling units as a single aircraft, having a fleet size of one per base, and treating a CIRF as a forward supply facility only.

The assumptions and workarounds were incorporated into two scenarios for the TACS for each ATAF in Germany. Each scenario reflected a different resupply policy. Data from REFORGER 83 was used to model the scenarios and verify the reasonableness of the output in versions 3.04 and 4.3.

V. Results

Overview

This chapter presents the results of the Dyna-METRIC modeling process. It begins with a review of the conclusions to the systems analysis, discusses applying Dyna-METRIC to mobile CE systems, presents results of verification runs and then the results of the initial model runs used to portray the TACS in USAFE. These initial runs reflected problems in using options 10 and 16, and in the way the forward supply location variables were input for the initial runs. Changes were made to the original methodology because of these problems. This chapter presents these changes, and then presents the results of model runs made following the changes.

Systems Analysis (Research Objective 1)

The first objective of this thesis was to conduct a systems analysis of the resupply system used for mobile radar units in Germany. Chapter 3 presented the analysis. It discussed the system elements, highlighted problems in the system, and then presented six alternative systems which would "fix" the problems which could occur during war in Europe.

Alternative 6, a combination of prepositioning spares in-theater to forward stock locations and enhancing available transportation assets, seemed to have the greatest potential for improving the resupply system. This conclusion was based on four factors: responsiveness to user requests, survivability of the system, maintainability of the system, and the ability of the system to reduce the uncertainty commanders of radar units faced when autonomously deployed for war. Alternative 6 had the potential to improve all four areas, and thus provide a better resupply system than the one currently used for TACS wartime support.

The second objective was to determine if the Dyna-METRIC model could be used to model CE systems. The results of this objective are presented next.

Applying Dyna-METRIC to CE Equipment (Research Objective 2)

This thesis represents the initial application and verification of the Dyna-METRIC model to CE systems and scenarios. Chapter 4 discussed the methodology used to verify the model, and then validate the results with respect to the data input for the mobile TACS. The results of the model runs verified the model could provide reasonable and useful assessments of CE systems.

Data from four TACS units, who deployed for REFORGER 83, were used to verify version 3.04 of the model. Seventeen stock numbers were analyzed, based on their demand history during REFORGER. The model was run for a 30 day period, and initially showed all four units able to operate during the period with no significant downtime (NMCS) caused by any of the seventeen parts. This matched the actual performance of the units during REGORGER.

After this initial run, some of the values were changed to see if the model would produce predictable results. Demands per flying hour were set up to over .025 on three stock numbers, and between .01 and .02 for ten others. The demand rates were not changed on the remaining four. Additionally, the flying hours per day were set to zero for deploying units (for five days) to reflect the time they were redeploying, and repair cycle times on all parts were reduced to .5 days from two days.

The model was run for a second 30 day period after the changes were made, and the results were as expected from the changes. The excessively high demand rate on thirteen of the stock numbers caused them to be problem parts on the first day of the scenario. The parts were listed as problem parts with the three numbers having a demand rate of over .025 listed first. These parts drove the "probability of zero percent NMCS" from .26 on day one, to .04 by day five. The corresponding expected number of sorties (operating hours) for all units went from 6.28 on day one to 1.07 on day five. The decline in both numbers to equivalent levels verified the mathematics of the model could be applied to scenarios of one "airplane" flying 24 one hour sorties each day. The smaller the probability there was of achieving 0%

NMCS, the less hours there were that units were able to operate during the day.

The expected number of airplanes available to "fly" the sorties started off at .74 on day one and decreased to .04 by day five. This figure was a reasonable compliment to the 4% probability of achieving 0% NMCS, and was interpreted to mean the unit had only a 4% chance to be FMC by day five. With only a 4% chance of being FMC, it seems reasonable to expect only about 1.07 hours worth of operating time to be achievable that day by the unit's equipment.

On the days that the units were scheduled for zero sorties, the number of backorders against them for parts began to decrease (as maintenance occurred without demands being placed). As soon as the units returned to operations, the NMCS rate began to rapidly climb again, and backorders began to occur. These combined results reflected the low repair cycle time (.5 days) and the rapid return of parts to the system when demands were not exceeding repair capability. As the number of backorders decreased, the probability of 0% NMCS increased for the nonflying units over the five days from .04 to 1.0. These results all were what should be expected from the model, if it was functioning properly.

The only unexpected result occurred when a CIRF was added in a third run of the model. The results with the CIRF were identical to the results without it, even though it cut transportation times in half, and added more stock to the system. At this point, no attempt was made to determine why this occurred. The primary intent of the verification runs was to validate the model for CE systems in general. Later runs would be made which required the use of a CIRF. If the problem repeated itself, then an attempt to find out why would be undertaken.

Overall it was concluded that version 3.04 logic provided realistic and useful results for the input data.

After these runs were made with version 3.04, the files were converted to version 4.3 formats using a conversion program written by HQ AFLC. The program supplied default values for variables in the 4.3 files which were not in the 3.04 files. The results of the 4.3 runs were nearly identical to the 3.04 runs. The differences were probably caused by more decimal places being carried and reported by version 4.3. For example, the probability of achieving a 0% NMCS was an average of .05% higher in the version 4.3 results. This slightly higher probability resulted in an average increase in backorders of .74 parts per unit per day.

These results were close enough to conclude that the basic 4.3 logic was valid to the same extent that 3.04 logic was valid. This answered research objective 2, because it appeared Dyna-METRIC could be used to model mobile CE systems. Therefore, actual values for all 15 TACS units, seventy WRSK stock numbers, SAB base supply, and the satellite supply account at HOAS were formatted for the task of analyzing alternative 6 from chapter 3 using version 4.3.

Comparing TACS Resupply Systems (Research Objective 3)

Additional Version 4.3 Features. Before discussing specific results to the Dyna-METRIC runs made to achieve objective 3, three additional features of version 4.3 that could not be verified in version 3.04 need to be discussed. These three features include: describing SAB as a depot, bootstrapping successive model runs, and defining a minimum QPA per part per unit which was needed to declare the unit FMC. The results of the scenario runs indicated the additional features were all working to a degree; however, there was no baseline data to compare them with to verify their correctness.

The minimum QPA feature played a significant role in the daily results. In any scenario, as long as the number of items backordered against a part number did not exceed the total stock available of the part, plus the minimum QPA, then all end items remained FMC, and the units were reported as FMC. An analysis of the problem LRU listing sometimes revealed the status of a unit could probably only be PMC, because of a degraded capability, but not yet NMC because redundant end items in the unit were still operating (for example, loss of two out of three UHF radios in a CRP). The minimum QPA value was the number of a part needed to keep at least one of each end item of equipment operating, without having to have all of the unit's equipment operating.

Options 10 and 16 worked together and allowed for making successive model runs based on the results from preceding runs. The output, however, reflected a problem in using the options. The number of parts in the unit pipelines, and the number of parts backordered at each unit decreased between the last day of an input file and the first day of the next file. The values should have increased, but in fact only continued to increase in the depot pipelines.

The results were presented to the Rand Corporation, who verified there was a problem in the FORTRAN code for the options (17). The "transportation times" variable which specifies travel times between bases and their supporting depots/CIRFs, was saved as a single value with option 16, but treated as a rate in option 10. The problem caused saved pipelines from the first file to be recomputed as the second file began, and the result was less parts in the pipelines. The problem will be corrected in version 4.4 which will be released to users in late August 1984 (17). The options did work partially , and with the change in the treatment of the "transportation time" variables, the options will provide a powerful capability to bootstrap file runs.

No problems were observed by modeling SAB as a depot. All the results for the depot appeared to be reasonable with respect to the inputs.

The third objective, using Dyna-METRIC to model the TACS and substantiate the benefits of forward supply points, was only partially met by the model runs of the TACS following the methodology in Chapter 4. The next section presents the inital results, and the impact of the problem with options 10 and 16.

Initial Results. (Note: This section describes the results based on errors in the methodology and model. The final sections of this chapter present corrections that were made, and a more detailed analysis of corrected results.)

The Northern region results are presented in table II. Runs one and four modeled the first scenario, the current TACS resupply system, using best and worst transportation times respectively. Runs two and three modeled the second scenario which reflected a policy where units provided all transportation between themselves and the forward supply location at HOAS, again with best and worst transportation times. The "cutoff switch" on the second card of each input file was the only variable changed between scenarios. It was set to one in the first scenario to show forward and retrograde pipelines to unit locations were cutoff while they redeployed, and set to zero in the second run to show that only the forward pipelines were cutoff. Runs two and

TABLE II

NORTHERN REGION: SCENARIO ONE AND TWO RESULTS

RUN	UNIT	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27
		DAYS																										
	606C	D	D	F	F	F	F	F	F	F	F	F	F	F	F	F	P	P	P	D	D	D	F	F	F	F	F	F
1	609C	F	F	F	F	F	F	F	F	F	F	F	D	D	F	F	F	F	F	F	F	F	F	F	F	F	F	F
	626F	D	D	F	F	F	F	F	F	F	F	F	F	F	D	D	F	F	F	F	F	F	F	D	F	F	F	F
&	636F	D	D	D	F	F	F	F	F	F	F	F	F	D	F	F	F	F	F	F	F	F	F	D	F	F	F	F
	619F	D	F	F	F	F	F	F	F	F	F	F	F	F	F	D	F	F	F	F	D	F	F	F	F	F	F	F
2	629F	F	F	F	F	F	D	F	F	F	F	F	F	F	F	F	F	F	F	F	F	F	F	F	F	F	D	F
Back-		1		3		5		7		9	10		12		14		16		18	19		21		23		25		27
orders		0		.12		.49		1.03		1.86	2.03		2.85		3.50		4.55		5.94	.69		1.21		1.95		3.13		4.3
best times																												
	606C	D	D	F	F	F	F	F	F	F	F	F	F	F	F	F	P	P	P	D	D	D	F	F	F	F	F	F
3	609C	F	F	F	F	F	F	F	F	F	F	F	F	F	F	F	F	F	F	F	F	F	F	F	F	F	F	F
	626F	D	D	F	F	F	F	F	F	F	F	F	F	F	D	D	F	F	F	F	F	F	F	D	F	F	F	F
&	636F	D	D	D	F	F	F	F	F	F	F	F	F	D	F	F	F	F	F	F	F	F	F	D	F	F	F	F
	619F	D	F	F	F	F	F	F	F	F	F	F	D	F	F	D	F	F	F	F	D	F	F	F	F	F	F	F
4	629F	F	F	F	F	F	D	F	F	F	F	F	F	F	F	F	F	F	F	F	F	F	F	F	F	F	D	F
Back-		1		3		5		7		9	10		12		14		16		18	19		21		23		25		27
orders		0.		.13		.53		1.12		1.99	2.01		2.82		3.58		4.50		5.85	.70		1.24		2.06		3.21		4.5
worst times		File 1									File 2									File 3								

F = FMC   P = PMC   N = NMC   D = DEPLOY three were identical to runs one and four respectively, so the results are not shown separately. This would indicate the "cutoff switch" was not sensitive to the proposed scenario, and opening the retrograde pipelines while deploying had no impact on the overall pipeline structure or capability of the units. The results probably indicate that although units could send assets to be repaired, they could not take any repaired items back with them to improve their unit capability. This is a limitation of the model which precludes evaluating a different transportation policy when a CIRF is included in the scenario.

The problem caused by options 10 and 16 is visible on day 19 of table 2. There was a loss of 5.25 parts in run one, and a loss of 5.15 parts in run four between days 18 and 19. Day 18 ended the second file, and day 19 began the third. This erroneous loss of parts partially invalidated the results of the initial runs. The differences in the number of backorders occurring each day between runs one and four were caused by replacing the best estimated transportation time (usually fractions of a day) with worst estimated times (usually one or two days). The results show variable transportation times do cause variable pipelines to occur. However, no conclusions could be drawn as to whether the second scenario decreased the variability from the first scenario, because the pipelines were erroneously adjusted by options 10 and 16. The overall mission capability of each unit, as shown, is probably also incorrect due to the adjusted pipelines and erroneous decreased backorders.

Table III presents the results of scenario one for the Southern region. The problems with options 10 and 16 are visible on days 10 and 19. As in the Northern region, the variation between best and worst times caused a variation in the number of backorders, and the pipelines. However, the status of each unit for each day is probably erroneous because of the pipeline adjustments made by options 10 and 16.

Table IV presents the results for scenario two in the south, which was identical to scenario one, except a forward stock location was added to the resupply system. The results for runs two and four (representing scenario two) are essentially identical to runs one and three on Table III. This appeared to indicate the forward stock had no significant impact on the pipelines or mission capability of units in the south.

This result was discussed with Rand, and they suggested it was caused by a misinterpretation of the "CIRF Reparability" variable on the LRU input cards (17). They suggested the variable should have been a one to indicate the CIRF could repair all the LRUs modeled. A value of zero had been used to indicate the CIRF had no repair capability for the LRUs, and was a forward stock location only. By using a value of zero, the CIRF was removed from

TABLE III

SOUTHERN REGION: SCENARIO ONE - NO FSL

RUN	UNIT	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27
															DAYS													
	601C	D	D	F	F	F	F	F	F	F	F	F	F	D	D	D	F	F	F	F	F	F	F	F	F	F	F	F
	602C	D	F	F	F	F	F	F	F	F	F	F	F	F	F	F	F	F	F	F	F	D	D	F	F	F	F	F
	603C	F	F	F	F	F	F	F	F	F	F	F	F	F	F	F	F	F	F	F	F	F	F	F	F	F	F	F
	612F	D	D	F	F	F	F	F	F	F	F	F	F	F	F	F	D	F	F	F	D	F	F	F	F	F	F	F
1	621F	F	F	F	F	F	F	F	D	F	F	F	F	F	F	F	F	F	F	D	F	F	F	F	F	F	F	F
	631F	D	D	F	F	F	F	F	F	F	F	F	D	F	F	F	F	F	F	F	F	F	F	D	F	F	F	F
	632F	D	D	F	F	F	D	F	F	F	F	F	F	F	F	F	F	D	F	F	F	F	F	F	F	F	F	F
	611F	F	F	F	F	F	F	F	F	F	F	D	F	F	F	F	F	F	F	F	F	D	F	F	F	F	F	F
	622F	F	F	F	F	F	F	F	F	F	F	F	F	F	D	F	F	F	F	F	F	F	F	F	F	F	D	F
	Back-	1		3		5		7		9	10		12		14		16		18	19		21		23		25		27
	orders	.14		.67		1.67		2.85		4.29	2.09		3.36		4.87		6.64		8.74	1.77		2.90		4.40		6.45		8.6
	601C	D	D	F	F	F	F	F	F	F	F	F	F	D	D	D	F	F	F	F	F	F	F	F	F	F	F	F
	602C	D	F	F	F	F	F	F	F	F	F	F	F	F	F	F	F	F	F	F	F	D	D	F	F	F	F	F
	603C	F	F	F	F	F	F	F	F	F	F	F	F	F	F	F	F	F	F	F	F	F	F	F	F	F	F	F
	612F	D	D	F	F	F	F	F	F	F	F	F	F	F	F	F	D	F	F	F	D	F	F	F	F	F	F	F
3	621F	F	F	F	F	F	F	F	D	F	F	F	F	F	F	F	F	F	F	D	F	F	F	F	F	F	F	F
	631F	D	D	F	F	F	F	F	F	F	F	F	D	F	F	F	F	F	F	F	F	F	F	D	F	F	F	F
	632F	D	D	F	F	F	D	F	F	F	F	F	F	F	F	F	F	D	F	F	F	F	F	F	F	F	F	F
	611F	F	F	F	F	F	F	F	F	F	F	D	F	F	F	F	F	F	F	F	F	D	F	F	F	F	F	F
	622F	F	F	F	F	F	F	F	F	F	F	F	F	F	D	F	F	F	F	F	F	F	F	F	F	F	D	F
	Back-	1		3		5		7		9	10		12		14		16		18	19		21		23		25		27
	orders	.14		.70		1.73		3.00		4.50	2.06		3.28		4.76		6.53		8.59	1.83		2.97		4.51		6.61		8.8
						File 1									File 2									File 3				

F = FMC   P = PMC   N = NMC   D = DEPLOY

TABLE IV

SOUTHERN REGION: SCENARIO TWO - FSL ADDED

RUN UNIT	DAY																									
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27
601C																											
602C																											
603C																											
612F																											
621F																											
631F																											
632F																											
611F																											
622F																											
Back-orders																											
601C																											
602C																											
603C																											
612F																											
621F																											
631F																											
632F																											
611F																											
622F																											
Back-orders																											
					File 1									File 2									File 3				

RESULTS IDENTICAL TO SCENARIO ONE

(SEE TABLE III)

the pipelines, and thus had no impact on the results of the second scenario.

The correct method to model a CIRF as a stock only facility would be to give "CIRF Reparability" a value of one, then input the CIRF Repair Time" as 0.0 days, and the "CIRF NRTS Rate" as 1.0. In this manner, all reparable parts would go from the unit, to the forward stock location. No repair would occur at the location, and the parts would be sent on the SAB (17).

Results of the initial runs verified that varying transportation times cause variation in the parts pipelines. However, the third objective, substantiating the forward stock locations as a means to decrease the variation in the pipelines, could not be accomplished because of the problems with options 10 and 16, and the incorrect value for the "CIRF Reparability" variable. To achieve the third objective, it was necessary to change the methodology presented in Chapter 4 and obtain new results for both regions. Due to time limitations, the authors could not wait for version 4.4 to be released, and then repeat their original methodology. An alternative method to partially repeat the methodology, and achieve research objective 3 was developed and applied.

Methodology Changes

The following changes were made to the file structure presented in figures 13 and 14.

1. The "CIRF Reparability" variable on all LRUs was changed from zero to one.

2. Options 10 and 16 were removed from the input.

3. Two additional variables which were not previously discussed were added to the LRU cards. "CIRF Repair Time", the number of days required to repair an LRU at the forward stock location, was set to 0.0. "CIRF NRTS Rate", the percentage of all parts entering repair at the forward stock location which could not be repaired and were sent on to the depot for repair, was set to 1.0 (or 100%).

4. Each run now consisted of only one input file. The third file in each series was used to make the runs. It was chosen simply for ease in making changes to the input values on an equivalent file in each run. Any of the three files in each run could have been used.

5. The runs were made using worst case transportation times only. The initial runs demonstrated variation occurred with changing times. The corrected runs needed only to show the impact of a forward stock location on the pipelines and the mission capability of each unit.

6. Runs lasted 90 days, as opposed to the 27 day duration previously used. The extended time was used to investigate impact beyond the first 30 days of a war, since the first 30 days showed little degradation, and provide results to discuss the secondary objective of evaluating

RUN	EXPLANATION
1	only one file days: 5 10 20 30 45 60 75 90 2 way cut-off worst times north scenario 1
2	only one file same days as run one 1 way cut-off worst times north scenario 2
3	only one file same days as run one no FSL worst times south scenario 1
4	only one file same days as run one FSL added worst times south scenario 2

Figure 15. Changes to Methodology

unit WRSKs. Figure 15 shows the experimental design of the changed methodology.

Results of the Changes

Tables V and VI present the results of runs using the changed methodology. The results include the forward stock locations as an active part of the resupply pipelines reflecting the changes to CIRF repairability fields on the LRU cards.

In the Northern region (table V), the results of run one and two were identical. This substantiated the initial result of the cutoff switch not being sensitive to the changes desired, and open retrograde pipelines when deploying do not change the pipeline structures. (Note: The units were deploying in this run, but the days they were deploying were not days when results were reported.) On day 30, units began to have NMCS equipment items which caused their overall status to be PMC, even though the model reported them to be FMC. For example, the units had all used their WRSK spare part number 5840-01-035-1166 by day 30. An additional failure of this part could have caused the radar to be NMCS. On days 30 through 90, three parts drove the units to be PMC. Part number 5840-01-035-1166 continued to be a problem, as did 5820-00-921-6565 (TRC-97 microwave van) and 5945-00-991-8258 (TSC-60 radio van). The result was a loss of one TRC-97 in each unit by day 90.

TABLE V

NORTHERN REGION: CORRECTED METHODOLOGY RESULTS

RUN	UNIT	DAY 5	10	20	30	45	60	75	90
	606C	F	F	F	P	P	P	P	P
	609C	F	F	F	P	P	P	P	P
1	626F	F	F	F	P	P	P	P	P
	636F	F	F	F	P	P	P	P	P
	619F	F	F	F	P	P	P	P	P
	629F	F	F	F	P	P	P	P	P
	Backorders	.97	3.27	8.26	16.75	41.7	75.14	115.06	160.80
	606C	F	F	F	P	P	P	P	P
	609C	F	F	F	P	P	P	P	P
	626F	F	F	F	P	P	P	P	P
	636F	F	F	F	P	P	P	P	P
	619F	F	F	F	P	P	P	P	P
	629F	F	F	F	P	P	P	P	P
	Backorders	.97	3.27	8.26	16.75	41.7	75.14	115.06	160.80

F = FMC   P = PMC   N = NMCS   D = DEPLOY

Additionally, the CRPs had lost nearly all their HF radio capability from the TSC-60 vans by day 90. The equivalent of all but one TSC-60 van at each CRP was NMCS, yet the unit was still PMC with one van operational.

In the Southern region (table VI), there were more units generating more operating time, and this resulted in more parts in all pipelines. However, the run made with the added stock in the forward stock location (run two) had noticeably less parts in the resupply pipelines than run one. In run two, at day 90, there was a full 7% decrease in the number of backorders when compared to run one. This resulted in some units being able to operate their equipment for more days in the war before they started to lose individual end items.

For example, on day 20, part number 5820-00-921-6565 had driven all CRPs and two FACPs to a loss of one TRC-97 van. However, with a forward stock location only one of the three CRPs had lost a TRC-97 van. The other CRPs were still FMC with all equipment operating. On day 30, units were all PMC in both scenarios. In scenario one, there were three problem parts driving loss of equipment: 5820-00-921-6565, 5840-01-035-1166 in the radar van, and 5945-00-991-8285 in the CRP TSC-60 vans. However, in scenario two only part number 5820-00-921-6565 was causing a problem. This meant that units were more degraded on day 30 without the forward stock than they were with the stock. By day 90, the units

TABLE VI

SOUTHERN REGION: CORRECTED METHODOLOGY RESULTS

RUN	UNIT	DAY 5	10	20	30	45	60	75	90
	601C	F	F	P	P	P	P	P	P
	602C	F	F	P	P	P	P	P	P
	603C	F	F	P	P	P	P	P	P
	612F	F	F	D	P	P	P	P	P
1	621F	F	F	F	P	P	P	P	P
	631F	F	F	F	P	P	P	P	P
	632F	F	F	F	P	P	P	P	P
	611F	F	F	P	P	P	P	P	P
	622F	F	F	P	P	P	P	P	P
	Backorders	1.06	4.20	13.32	30.48	75.19	132.85	200.09	275.37
	601C	F	F	F	P	P	P	P	P
	602C	F	F	P	P	P	P	P	P
	603C	F	F	F	P	P	P	P	P
	612F	F	F	D	P	P	P	P	P
	621F	F	F	F	P	P	P	P	P
	631F	F	F	F	P	P	P	P	P
	632F	F	F	F	P	P	P	P	P
	611F	F	F	P	P	P	P	P	P
	622F	F	F	P	P	P	P	P	P
	Backorders	1.04	3.91	11.44	26.17	66.81	121.08	185.43	258.30

F = FMC P = PMC D = DEPLOY N = NMCS

in both scenarios were down to a single TRC-97, a single TSC-60 van in the CRPS, and a marginal radar. But in the second scenario, the units had more generators and UHF vans than in the first scenario. Overall unit capability was enhanced by having the forward stock available.

In summary, the third objective was answered by results from both the initial and corrected runs. In the initial runs, pipeline quantities varied as transportation times varied in each scenario. In the corrected runs, the addition of a forward stock location in the south had the effect of decreasing the amount of parts in the resupply pipelines, and improving unit operating capability somewhat. Version 4.4 will need to be used to determine the effect of both changes in transportation times and the addition of a forward supply location in a single model run.

<u>WRSK Analysis</u>

The secondary objective of evaluating the unit WRSK was met only with respect to the seventy WRSK NSNs modeled. The corrected runs showed the WRSK provided ample support to the units for the first 30 days, and continued to support the unit beyond 30 days. While degradation of unit equipment occurred, at no time during the 90 day runs did any unit lose its ability to still be PMC by NATO standards.

While these results are encouraging, several assumptions were made which could impact on the results. First, units began day one of the war with a fully stocked

WRSK. Second, only 8% of each unit's WRSK was randomly selected to model. If units go to war with less than a full WRSK, then the results could be entirely different. For example, part number 5840-01-035-1166 from the radar was a problem part, because the units used their single WRSK part as a replacement spare before day 20. Had any unit deployed without this spare they could have had an NMCS radar before day 30.

The real impact of the problem WRSK items occurs with the long production lead times required to provide spares from industry to the depots to fill the pipelines back to the units. All of the problem parts causing outages in the corrected scenario were identified also as critical items by base supply at Sembach on an R-29 Critical Item Report (5) dated 8 June 1984. For each item, the status given by the ALCs for backordered parts was "Backordered for Procurement" (BP). The time between the date the order was placed for a spare, and the date projected by the ALC for filling the order averaged over 500 days per part. The impact of the long lead times means once units use up their spares that could cause them to be NMCS, then they may not receive replacements for six months to a year.

Summary

The first objective of this thesis was to identify, through a systems analysis, a better way to support TACs units during war. This result was a resupply system which included forward stock locations and enhanced transportation. The second objective was to determine if Dyna-METRIC could be used to model the better system and substantiate the proposal. In conjunction with verification runs of the model, it was determined that Dyna-METRIC could provide reasonable and useful assessments of mobile CE systems. The final objective was to use Dyna-METRIC to model the TACS and substantiate the "best" means of resupply. The ultimate result was a clear improvement in the supply system with forward stock locations added. Finally, the model partially assessed the unit WRSKs because only WRSK NSNs were evaluated. This limited assessment indicated the WRSK could support the unit operating schedule for 30 days, but was based only on a random sample of seventy stock numbers, and assumed the units deployed with a full WRSK on day one of the war.

VI. Conclusions

Overview

This chapter presents the conclusions to the research objectives set in chapter 1, as achieved by the methodologies used in chapters 3 and 4. The conclusion to research objective 1 was the selection of forward stockage points with an improved transportation system to support these locations. This information was included in chapter 3, and is briefly restated in this chapter. Next is a discussion of how the Dyna-METRIC model can be applied to mobile CE systems, which includes specific recommendations for future Air Force application. The last section of the chapter discusses the recommended method to improve the wartime support of the TACS.

Summary of Research Effort

The 15 mobile radar units of the USAFE TACS have a wartime mission as a back-up command and control system in the NATO Air Defense Ground Environment (ADGE). Their chief means of survival is their mobility, but the frequent redeployments they undertake create unique resupply problems.

The current wartime resupply plans call for six of the units in Northern Germany to be resupplied by base supply at Sembach AB through a satellite supply account at Hessisch-Olendorf AS. The nine TACS units in Southern Germany will be directly supplied by base supply at SAB. There is no satellite supply account in Southern Germany. Sembach will be responsible for spares support of the TACS, regardless of where they deploy for a war in Europe, or how frequently they redeploy. Because this will require transportation over heavily controlled air and ground routes, TACS unit commanders cannot be certain the parts they order will arrive in a timely manner. In fact, the unit may redeploy before parts can be delivered, and the delivery driver may have no idea of the new unit location.

Because of this uncertainty, there is a need to know if there is a reasonable method of improving the resupply structure that supports the USAFE TACS.

This thesis sought to evaluate methods of improving TACS resupply through three research objectives: 1) conduct a systems analysis of the TACS to select a "best" resupply system from reasonable alternative systems, 2) determine if the Dyna-METRIC model could be used to evaluate the selected best system, and 3) use the Dyna-METRIC model to evaluate the current resupply system against the selected alternative system.

Objective one, presented in Chapter 3, was obtained by an analysis of all the elements of the resupply system. Six alternative systems were proposed that could possibly improve the resupply support provided by the current system. Alternative six was selected as having the most potential to improve the system. This alternative called for prepositioning WRSK spares at forward supply locations in Germany, and enhancing transportation resources between the units, base supply, and the forward supply locations.

Objective two was obtained through a verification process of the Dyna-METRIC model. Data from REFORGER 83 was used in version 3.04 of the model to see if 3.04 could provide reasonable and useful results with respect to the data, and actual unit performance during REFORGER. Although version 3.04 logic has only been shown to be valid for aircraft systems, the results obtained from the TACS data were also considered valid because they matched the performance of the units during REFORGER, and because the model functioned in a reasonable manner for the scenario modeled. Changes were made to the data that should cause known outcomes from the model (i.e., increasing demand rates), and when rerun with the changes, the results were expected.

The data was converted to a format for use with version 4.3, because 4.3 was to be used in objective 3 and it has not yet been validated. The model was rerun, and the output from version 4.3 closely matched the output of version 3.04, which meant 4.3 logic was valid with respect to the valid 3.04 results.

The final research objective was obtained by modeling the 15 units, Sembach AB base supply, HOAS, and a hypothetical forward supply location using version 4.3. The analysis was conducted using data from seventy stock numbers chosen randomly from the unit WRSK authorization. Initial results of the model runs reflected problems in two areas: 1) the FORTRAN code for option 10 was incorrect, so the model could not bootstrap successive runs together to provide for continuous results between runs, and 2) the forward supply locations were incorrectly input for the model runs, which caused them not to be considered in the model calculations.

Because of these problems, the methodology was changed to correct the forward supply location input, and run the model without option 10. The corrected methodology was used in obtaining results for objective three. Essentially, the results indicated a forward supply location in Southern Germany could improve the resupply support of TACS units during war.

The remainder of this chapter draws conclusions from the results of each research objective.

System Analysis (Research Objective 1)

Conclusion. Based on the four criteria used to evaluate each of the six proposed alternative resupply systems, alternative 6 was selected as the "best" resupply system for use with the TACS. This alternative was to use forward resupply points to preposition stocks, and use dedicated transportation assets from the 601 TCW to support the resupply points. It was the subjective opinion of the authors that use of this alternative would result in a resupply system that would be 1) more maintainable by the 601 TCW, 2) more survivable, 3) more responsive to unit needs, and 4) reduce resupply uncertainty faced by TACS unit commanders.

Applying Dyna-METRIC to CE Equipment (Research Objective 2)

Conclusions. Dyna-METRIC can be used to assess the wartime capabilities of mobile CE systems, although some limitations remain as discussed in the limitations section in Chapter 4. The most difficult task in preparing the model is collecting and reducing data on CE systems into the format used by Dyna-METRIC. Because there is no centralized management system to do this for all equipment worldwide, such as the D029 system for aircraft spares, users will need to collect data from the wholesale and retail supply functions supporting the system to be modeled. For a complex system, this may prove to be an overwhelming task.

Once the data is collected, realistic results can be obtained by analyzing separate equipment end items and their supporting WRSK individually, or combining several end items in a single unit into a composite "aircraft" supported by a composite WRSK. In either method, the number of aircraft supported on a base is equal to the number of end items on the base (i.e., 5 UHF vans equals 5 aircraft if only the vans are being analyzed), or the total number of units possessing the composite set of equipment on the base (usually 1). The number of sorties to fly each day should equal the desired number of operating hours, and each sortie should be given a length of one hour. Other possible ways to manipulate the variables to match mobile CE system scenarios are presented in the variables section of chapter 4.

The results of the Dyna-METRIC runs using the collected data will only be as accurate as the data itself. Care should be taken when computing the demands per operational hour so that the demands are not incorrectly stated due to miscalculating the total hours operated or the QPA for each stock number on the end items of equipment. The fewer end items evaluated in each run, the more accurate the results may be, due to less subjective judgements required on the status of equipment.

With these methods, several Air Force systems can be evaluated by Dyna-METRIC, and the results used in wartime planning for the employment/deployment of the systems. The following systems (units) could be evaluated: mobile Combat Communications Groups, Combat Control Teams, all elements of the TACS (radar and non-radar equipped units), and Ground Launched Cruise Missile systems. While only mobile CE systems were evaluated during the research, the same techniques and methodology may apply to fixed CE installations as well.

Recommendations. AFLC, in conjunction with the Sacramento ALC, needs to establish a permanent system to track and store usage data on CE systems and associated parts. The system should be similar to the current D029 system, and provide CE system users a basis to prepare WRM support kits/sets so the current subjective evaluation system could be dropped.

AFLC and AFCC should experiment with data from other mobile and fixed CE systems on better ways to apply Dyna-METRIC to assess combat capability of communications equipment. The workarounds and methods developed during research for this thesis provide a basis for analyzing these systems.

One change in the model could resolve many of the workarounds required to model the TACS. In particular, AFLMC or Rand should evaluate ways to model multiple MDS systems (aircraft or CE systems) on a single base in Dyna-METRIC. If this capability existed, CE units would not need to be modeled as a composite aircraft of separate end items, but could be modeled with all of their end items considered separately in a single model run. The result would be a much clearer picture of unit capability without the subjective statements required on the status of each end item of equipment in the unit. This feature could also be developed to allow users to account for the cannibalization that occurs between different MDS end items of equipment in a CE system.

An additional change to the cutoff switch could allow more flexibility when modeling mobile systems. Currently the switch allows users to cutoff both forward and retrograde pipelines, or forward only. A useful change would be to allow for selectively opening and closing the pipelines between system elements in either direction. This would allow users the flexibility to change the pipelines as needed when units deploy.

The MINDM model created by the AFLMC has great potential for use in analysis of small, autonomous CE units such as the elements of the TACS. USAFE and TAC should experiment with using MINDM to evaluate individual radar squadrons and flights. A possible method would be to evaluate one end item (such as the TPS-43E radar and van) and its supporting WRSK at a time. Radar units with microcomputers could conduct regular MINDM assessments of their wartime capabilities.

AFLMC should work to incorporate more of the features of version 4.3 into future versions of their MINDM. Useful features to have in MINDM include: being able to model a CIRF, inputting a minimum QPA, having a partial cannibalization capability, specifying condemnation rates and procurement lead times for each LRU/SRU, and being able to specify a unique repair cycle time for each part modeled.

Comparing TACS Resupply Systems (Research Objective 3)

Conclusions. Prepositioning forward stocks at specific forward supply points can improve the resupply support of the USAFE TACS. During the system analysis the rationale and benefits of using forward supply points subjectively supported prepositioning as a viable concept. Along with the forward supply points, dedicated transportation assets from the 601 TCW to support these resupply points adds additional refinement to the resupply system critical to its success. The results of the Dyna-MERTIC analysis further substantiated adoption of the prepositioning concept, and added additional credence to the subjective systems analysis results. The results of the model runs showed that adding a resupply point (along with additional stock) in the Southern region significantly reduced the amount of spares in the resupply pipelines, thus improving resupply support for that region. The results of the model also supported HOAS as a viable, useful resupply facility, because of the improvements shown in the Southern region when a forward supply location was added to the scenario. It should continue to be maintained as a forward supply location.

Recommendations. It is highly recommended that the 601 TCW implement the resupply system proposed by the authors.

The 601 TCW, with the approval of USAFE, should begin surveying sites for possible use as forward supply points. Sites already under the control of the 601 TCW should be considered first, but if these sites do not prove satisfactory, other US controlled sites should be surveyed. Because this thesis was time constrained, only two forward supply points were evaluated in the model. Further analysis may prove a mix of three or four forward supply points to be the optimum mix.

Upon selection of sites, these forward supply points should be funded, and provided with facilities, personnel, and stockage of all materials consumed by the TACS in sufficient amounts to obtain the necessary support level for the region they support. Forward supply points should become operational as soon as possible, and operate in peacetime, acting as intermediate supply facilities between Sembach AB and the individual TACS units. In this manner the resupply system used in peacetime will be the same system used in wartime. This arrangement should enhance TACS resupply support performance during a contingency. USAFE/AAFCE warplans should then be updated to include forward supply point locations and procedures for their operations.

If the above recommendations are followed, the resupply system will be 1) more maintainable by the 601 TCW 2) more survivable to counter system disruptions 3) more responsive to unit needs, and 4) provide a more concrete system for unit commanders to work with, thus reducing the amount of uncertainty they experience under the current system. The ultimate result of an enhanced resupply system will be an improved operational capability of the entire TACS, and an increased effectiveness of the NATO air defense system.

Appendix A: Input Files

Initial Methodology Input Files

This section contains copies of the files used to conduct the methodology described in Chapter 4. The files are presented by region and scenario. The first file for scenario one in each region is displayed, followed first by the changes made to files two and three for region, then by changes made in all three files in scenario two.

After the scenario portion of the files are discussed, then the LRU data used in all the files (Northern and Southern regions) is presented. The LRU, VTM, APPL, and the STK cards used in the Northern region were identical in both scenarios, and are displayed only once. In the Southern region, the LRU and VTM cards were the same as those used in the Northern region and are not repeated. The APPL and STK cards were different in the Southern region because of the different units modeled. Both groups of APPL and STK cards are presented for both Southern scenarios.

Northern Scenario One.

File One.

```
THESIS: AFIT/GLM/LSM/84S43  CAPT R D MABE AND CAPT R E ORMSTON
11.900                 VERSION 4.3  NT1NT2NT3NT4NT5
   1    2    3    4    5    6    7    8    9
OPT
       8 70
      11  0.80
      15
      16
DEPT
SAB                                    180.01          180. 180. 180. 0      10.00
CIRF
HOAS                                        1                         0      1.00
BASE
606CHOAS2.0002.0001.00 01.00 3.00                      1.0001.0001.00000.0  1.00     1
609CHOAS1.0001.0001.00 01.00 3.00                      1.0001.0001.00000.0  1.00     1
626FHOAS2.0002.0001.00 01.00 3.00                      1.0001.0001.00000.0  1.00     1
636FHOAS2.0002.0001.00 01.00 3.00                      1.0001.0001.00000.0  1.00     1
619FHOAS1.0001.0001.00 01.00 3.00                      1.0001.0001.00000.0  1.00     1
629FHOAS1.0001.0001.00 01.00 3.00                      1.0001.0001.00000.0  1.00     1
TRNS
HOAS SAB   .250   .250  0 1.0    180.   1.0
606C SAB  2.500 2.500 0 3.0    180.   1.0
609C SAB  1.500 1.500 0 3.0    180.   1.0
626F SAB  2.500 2.500 0 3.0    180.   1.0
636F SAB  2.500 2.500 0 3.0    180.   1.0
619F SAB  1.500 1.500 0 3.0    6.00   1.0
629F SAB  1.500 1.500 0 3.0    180.   1.0
ACFT
606C  0.    1  1.   99   0.
609C  0.    1  1.   99   0.
626F  0.    1  1.   99   0.
636F  0.    1  1.   99   0.
619F  0.    1  1.   99   0.
629F  0.    1  1.   99   0.
SRTS
606C  0.    10.0     324.0
609C  0.    124.0
626F  0.    10.0     324.0
636F  0.    10.0     424.0
619F  0.    10.0     224.0    60.0    724.0
629F  0.    10.0     224.0
FLHR
606C 0.     1 1.0  99 0.
609C 0.     1 1.0  99 0.
626F 0.     1 1.0  99 0.
636F 0.     1 1.0  99 0.
619F 0.     1 1.0  99 0.
629F 0.     1 1.0  99 0.
ATTR
606C0.       10.       990.
609C0.       10.       990.
626F0.       10.       990.
636F0.       10.       990.
619F0.       10.       990.
629F0.       10.       990.
TURN
606C24.01 990.
609C24.01 990.
626F24.01 990.
636F24.01 990.
619F24.01 990.
629F24.01 990.
```

Worst estimated times are shown on the BASE cards (columns 9 to 18) and the TRNS cards (columns 11 to 21). The best estimated times used in file one were:

BASE			TRNS		
606C	.2083	.2083	606C	.3334	.3334
609C	.2500	.2500	609C	.2500	.2500
626F	.2083	.2083	626F	.5000	.5000
636F	.1250	.1250	636F	.3750	.3750
619F	.0417	.0417	619F	.3334	.3334
629F	.1250	.1250	629F	.2917	.2917

File Two. File two was identical to file one, except for the following cards:

- line 3, reporting days:

  10 11 12 13 14 15 16 17 18

- BASE cards (columns 9 to 18) transportation times to and from HOAS:

best times			worst times		
BASE			BASE		
606C	.2083	.2083	606C	1.000	1.000
609C	.2917	.2917	609C	2.000	2.000
626F	.1067	.1067	626F	1.000	1.000
636F	.1250	.1250	636F	1.000	1.000
619F	.0833	.0833	619F	1.000	1.000
629F	.1250	.1250	629F	1.000	1.000

- TRNS cards (columns 12 to 21) transportation times to and from SAB:

best times			worst times		
TRNS			TRNS		
606C	.3334	.3334	606C	2.000	2.000
609C	.2083	.2083	609C	2.000	2.000
626F	.4583	.4583	626F	2.000	2.000
636F	.3750	.3750	636F	2.000	2.000
619F	.2917	.2917	619F	2.000	2.000
629F	.2917	.2917	629F	2.000	2.000

- TRNS cards cutoff days and durations:

	day cutoff (col 31 to 35)	cutoff duration (col 37 to 41)
TRNS		
606C	180.	1.00
609C	12.0	2.00
626F	14.0	2.00
636F	13.0	1.00
619F	180.	1.00
629F	15.0	1.00

- SRTS cards, days flying hours were set to 0 while the units were redeploying:

SRTS

606C	no down days
609C	day 12, back to 24 sorties on day 14
626F	day 14, back to 24 sorties on day 16
636F	day 11, back to 24 sorties on day 12
619F	no down days
629F	day 15, back to 24 sorties on day 16

<u>File Three</u>. File three was identical to file one, except for the following cards:

- line 3, reporting days:
  19 20 21 22 23 24 25 26 27

- BASE cards (columns 9 to 19) transportation times to and from HOAS:

best times			worst times		
BASE			BASE		
606C	.1667	.1667	606C	1.000	1.000
609C	.2917	.2917	609C	2.000	2.000
626F	.2500	.2500	626F	2.000	2.000
636F	.1667	.1667	636F	1.000	1.000
619F	.0833	.0833	619F	1.000	1.000
629F	.1667	.1667	629F	1.000	1.000

- TRNS cards (columns 11 tp 21) transportation times to and from SAB:

best times			worst times		
TRNS			TRNS		
606C	.3750	.3750	606C	2.000	2.000
609C	.2083	.2083	609C	2.000	2.000
626F	.5417	.5417	626F	2.000	2.000
636F	.4166	.4166	636F	2.000	2.000
619F	.2917	.2917	619F	2.000	2.000
629F	.3334	.3334	629F	2.000	2.000

- TRNS cards cutoff day and cutoff duration:

	day cutoff (col 31 to 35)	cutoff duration (col 37 to 41)
TRNS		
606C	19.0	3.0
609C	180.	1.0
626F	23.0	1.0
636F	23.0	1.0
619F	20.0	1.0
629F	26.0	1.0

- SRTS cards, days flying hours were set to 0 while the unit was redeploying:

```
SRTS
606C  day 19, back to 24 sorties on day 22
609C  no down days
626F  day 23, back to 24 sorties on day 24
636F  day 23, back to 24 sorties on day 24
619F  day 20, back to 24 sorties on day 21
629F  day 26, back to 24 sorties on day 27
```

<u>Northern Scenario Two</u>. All files used in scenario two were identical to those used in scenario one, except the second line of each file was changed to read:

```
01.500            VERSION 4.3 MT1MT2MT3MT4MT5
```

<u>Southern Scenario One</u>.

<u>File One</u>.

```
THESIS: AFIT/GLM/LSM/84S43  CAPT R D MABE AND CAPT R E ORMSTON
11.500               VERSION 4.3  MT1MT2MT3MT4MT5
  1   2   3   4   5   6   7   8   9
OPT
     8 70
    11  0.80
    15
    16
DEPT
SAB                                   180.01           180. 180. 180. 0     10.00
BASE
601C                                                   1.0001.0001.00000.0  1.00     1
602C                                                   1.0001.0001.00000.0  1.00     1
603C                                                   1.0001.0001.00000.0  1.00     1
612F                                                   1.0001.0001.00000.0  1.00     1
621F                                                   1.0001.0001.00000.0  1.00     1
631F                                                   1.0001.0001.00000.0  1.00     1
632F                                                   1.0001.0001.00000.0  1.00     1
611F                                                   1.0001.0001.00000.0  1.00     1
622F                                                   1.0001.0001.00000.0  1.00     1
TRNS
601C SAB  2.000 2.000 0 3.0   180.  1.0
602C SAB  2.000 2.000 0 3.0   180.  1.0
603C SAB  1.000 1.000 0 3.0   180.  1.0
612F SAB  2.000 2.000 0 3.0   180.  1.0
621F SAB  2.000 2.000 0 3.0   8.00  1.0
631F SAB  2.000 2.000 0 3.0   180.  1.0
632F SAB  2.000 2.000 0 3.0   6.00  1.0
611F SAB  1.000 1.000 0 3.0   180.  1.0
622F SAB  1.000 1.000 0 3.0   180.  1.0
ACFT
601C  0.    1  1.9999  0.
602C  0.    1  1.9999  0.
603C  0.    1  1.9999  0.
612F  0.    1  1.9999  0.
621F  0.    1  1.9999  0.
631F  0.    1  1.9999  0.
632F  0.    1  1.9999  0.
611F  0.    1  1.9999  0.
622F  0.    1  1.9999  0.
SRTS
601C  0.    10.0     324.0
602C  0.    10.0     224.0
603C  0.    124.0
612F  0.    10.0     324.0
621F  0.    124.0    80.0     924.0
631F  0.    10.0     324.0
632F  0.    10.0     324.0    60.0     724.0
611F  0.    124.0
622F  0.    124.0
```

```
FLMR
601C 0.    1 1.09999 0.
602C 0.    1 1.09999 0.
603C 0.    1 1.09999 0.
612F 0.    1 1.09999 0.
621F 0.    1 1.09999 0.
631F 0.    1 1.09999 0.
632F 0.    1 1.09999 0.
611F 0.    1 1.09999 0.
622F 0.    1 1.09999 0.
ATTR
601C0.      10.    99990.
602C0.      10.    99990.
603C0.      10.    99990.
612F0.      10.    99990.
621F0.      10.    99990.
631F0.      10.    99990.
632F0.      10.    99990.
611F0.      10.    99990.
622F0.      10.    99990.
TURN
601C24.0  990.
602C24.0  990.
603C24.0  990.
612F24.0  990.
621F24.0  990.
631F24.0  990.
632F24.0  990.
611F24.0  990.
622F24.0  990.
```

Worst times between SAB and the units are shown on the TRNS cards (columns 11 to 21). There are no transportation times on the BASE cards, because there was not an FSL in the first scenario for the Southern region. Best times used on the TRNS cards were:

```
TRNS
601C .0833 .0833
602C .2083 .2083
603C .0208 .0208
612F .1667 .1667
621F .2083 .2083
631F .5000 .5000
632F .4167 .4167
611F .1667 .1667
622F .2083 .2083
```

File Two. File two was identical to file one, except for the following cards:

- line 3, reporting days:
  10 11 12 13 14 15 16 17 18

- TRNS cards (columns 11 to 21) transportation times to and from SAB:

best times	worst times
TRNS	TRNS
601C .0833 .0833	601C 2.000 2.000

602C	.2083	.2083	602C	2.000	2.000
603C	.0208	.0208	603C	1.000	1.000
612F	.1250	.1250	612F	2.000	2.000
621F	.2500	.2500	621F	2.000	2.000
631F	.4583	.4583	631F	2.000	2.000
632F	.2916	.2916	632F	2.000	2.000
611F	.1667	.1667	611F	1.000	1.000
622F	.2500	.2500	622F	1.000	1.000

- TRNS cards cutoff days and cutoff duration:

TRNS	day cutoff (col 31 to 35)	cutoff duration (col 37 to 41)
601C	12.0	4.0
602C	180.	1.0
603C	180.	1.0
612F	16.0	1.0
621F	180.	1.0
631F	12.0	1.0
632F	17.0	1.0
611F	11.0	1.0
622F	14.0	1.0

- SRTS cards, days flying hours were set to 0 while the unit was redeploying:

SRTS	
601C	day 12, back to 24 sorties on day 16
602C	no down days
603C	no down days
612F	day 16, back to 24 sorties on day 17
621F	no down days
631F	day 12, back to 24 sorties on day 13
632F	day 17, back to 24 sorties on day 18
611F	day 11, back to 24 sorties on day 12
622F	day 14, back to 24 sorties on day 15

File Three. File three was identical to file one, except for the following cards:

- line 3, reporting days:
  19 20 21 22 23 24 25 26 27

- TRNS cards (column 11 to 21) transportation times to and from SAB:

best times			worst times		
TRNS			TRNS		
601C	.0833	.0833	601C	2.000	2.000
602C	.3334	.3334	602C	2.000	2.000
603C	.0208	.0208	603C	1.000	1.000
612F	.1250	.1250	612F	2.000	2.000
621F	.2916	.2916	621F	2.000	2.000
631F	.4583	.4583	631F	2.000	2.000
632F	.3334	.3334	632F	2.000	2.000
611F	.2083	.2083	611F	1.000	1.000
622F	.2500	.2500	622F	1.000	1.000

- TRNS cards cutoff day and cutoff duration:

	day cutoff (col 31 to 35)	cutoff duration (col 37 to 41)
TRNS		
601C	180.	1.0
602C	21.0	2.0
603C	180.	1.0
612F	20.0	1.0
621F	19.0	1.0
631F	23.0	1.0
632F	180.	1.0
611F	21.0	1.0
622F	26.0	1.0

- SRTS cards, days flying hours were set to 0 while the unit was redeploying:

SRTS	
601C	no down days
602C	day 21, back to 24 sorties on day 23
603C	no down days
612F	day 20, back to 24 sorties on day 21
621F	day 19, back to 24 sorties on day 20
631F	day 23, back to 24 sorties on day 24
632F	no down days
611F	day 21, back to 24 sorties on day 22
622F	day 26, back to 24 sorties on day 27

<u>Southern Scenario Two</u>. All files used in the second scenario were identical to those used in the first, except line 2 was changed to read:

```
01.500              VERSION 4.3 MT1MT2MT3MT4MT5
```

a CIRF card was added to model the FSL:

```
CIRF
SUAS                                   1                        0    1.00
```

and transportation times to and from the FSL (named SUAS) were added to the BASE cards (columns 9 to 18):

```
            best times            worst times

File One:
     BASE                     BASE
     601C .1667 .1667         601C 1.000 1.000
     602C .3334 .3334         602C 1.000 1.000
     603C .0833 .0833         603C 1.000 1.000
     612F .2083 .2083         612F 1.000 1.000
     621F .0833 .0833         621F 1.000 1.000
     631F .2416 .2416         631F 1.000 1.000
     632F .1667 .1667         632F 1.000 1.000
     611F .1667 .1667         611F 1.000 1.000
     622F .0833 .0833         622F 1.000 1.000

File Two:
     601C .2500 .2500         (all worst times same
     602C .3334 .3334          as file one)
     603C .0833 .0833
     612F .1667 .1667
     621F .0833 .0833
     631F .2500 .2500
     632F .1250 .1250
     611F .1250 .1250
     622F .1250 .1250

File Three:
     601C .2500 .2500        (all worst times same
     602C .5000 .5000         as file one)
     603C .0833 .0833
     612F .1667 .1667
     621F .1250 .1250
     631F .2500 .2500
     632F .1667 .1667
     611F .1667 .1667
     622F .1250 .1250
```

Stock Number Data. The LRU and VTM cards used in all scenarios were identical for the Northern and Southern regions. The values used are shown below:

```
LRU
5895-00-400-8106 SAB  1 0 01 01 0 .00016         1.0  0.0  0.00 1.0  0.0  0.00
5895-00-400-8106                180. 99.0       180. 180. 623.15    TPS43EC 1
5840-00-162-1231 SAB  1 0 01 01 0 .00113         1800 .470 0.00 1800 .470 0.00
5840-00-162-1231                180. 99.0       180. 180. 53817.50 TPS43EC 1
5960-00-078-0684 SAB  1 0 01 01 0 .00099         3.00 .920 0.00 3.00 .920 0.00
5960-00-078-0684                180. 99.0       180. 180. 48523.30 TPS43EC 1
5840-00-396-1208 SAB  1 0 01 01 0 .00154         8.00 .160 0.00 8.00 .160 0.00
5840-00-396-1208                180. 99.0       180. 180. 300.76    TPS43EC 1
5840-00-572-1617 SAB  1 0 01 01 0 .00090         1200 .190 0.00 1200 .190 0.00
5840-00-572-1617                180. 99.0       180. 180. 21408.55 TPS43EC 1
5840-01-027-0315 SAB  1 0 01 01 0 .00066         2800 .600 0.00 2800 .600 0.00
5840-01-027-0315                180. 99.0       180. 180. 14690.98 TPS43EC 1
5840-01-034-4607 SAB  1 0 01 01 0 .00021         9.00 .800 0.00 9.00 .800 0.00
5840-01-034-4607                180. 99.0       180. 180. 32450.15 TPS43EC 1
5840-01-035-1166 SAB  1 0 01 01 0 .00209         1.00 .980 0.00 1.00 .980 0.00
5840-01-035-1166                180. 99.0       180. 180. 3234.20   TPS43EC 1
5895-00-400-8104 SAB  1 0 01 01 0 .00027         1700 0.00 0.00 1700 0.00 0.00
5895-00-400-8104                180. 99.0       180. 180. 516.64    TPS43EC 1
5895-00-400-8108 SAB  1 0 01 01 0 .00036         1000 .460 0.00 1000 .460 0.00
5895-00-400-8108                180. 99.0       180. 180. 1089.74   TPS43EC 1
5840-01-037-5526 SAB  1 0 01 01 0 .00023         1900 .570 0.00 1900 .570 0.00
5840-01-037-5526                180. 99.0       180. 180. 26079.60 TPS43EC 1
5840-01-055-9558 SAB  1 0 01 01 0 .00083         6.00 0.00 0.00 6.00 0.00 0.00
5840-01-055-9558                180. 99.0       180. 180. 4381.49   TPS43EC 1
6130-00-443-6963 SAB  1 0 06 03 0 .00025         3.00 .620 0.00 3.00 .620 0.00
6130-00-443-6963                180. 99.0       180. 180. 1158.75   24U-8C  1
6115-00-456-3904 SAB  1 0 06 03 0 .00046         2.00 .950 0.00 2.00 .950 0.00
6115-00-456-3904                180. 99.0       180. 180. 14028.60 24U-8C  1
6110-00-442-7513 SAB  1 0 06 03 0 .00055         8.00 .620 0.00 8.00 .620 0.00
6110-00-442-7513                180. 99.0       180. 180. 1446.00   24U-8C  1
6110-00-442-7488 SAB  1 0 06 03 0 .00066         1200 .310 .308 1200 .310 .308
6110-00-442-7488                180. 99.0       180. 180. 752.62    24U-8C  1
6110-00-442-7478 SAB  1 0 06 03 0 .00034         9.00 .160 .164 9.00 .160 .164
6110-00-442-7478                180. 99.0       180. 180. 165.02    24U-8C  1
2910-00-109-2539 SAB  1 0 06 03 0 .00026         1000 .450 .373 1000 .450 .373
2910-00-109-2539                180. 99.0       180. 180. 357.50    24U-8C  1
6110-00-442-7469 SAB  1 0 06 03 0 .00045         7.00 .120 .062 7.00 .120 .062
6110-00-442-7469                180. 99.0       180. 180. 215.72    24U-8C  1
6110-00-442-7477 SAB  1 0 06 03 0 .00054         5.00 .270 .265 5.00 .270 .265
6110-00-442-7477                180. 99.0       180. 180. 196.28    24U-8C  1
5820-00-917-6578 SAB  1 0 08 02 0 .00031         5.00 .670 0.00 5.00 .670 0.00
5820-00-917-6578                180. 99.0       180. 180. 2054.85   TRC-97  1
5820-00-917-8303 SAB  1 0 08 02 0 .00041         1000 .160 0.00 1000 .160 0.00
5820-00-917-8303                180. 99.0       180. 180. 3091.00   TRC-97  1
5820-00-921-6562 SAB  1 0 08 02 0 .00010         3.00 .600 0.00 3.00 .600 0.00
5820-00-921-6562                180. 99.0       180. 180. 1462.00   TRC-97  1
5820-00-921-6565 SAB  1 0 08 02 0 .00103         1700 .230 0.00 1700 .230 0.00
5820-00-921-6565                180. 99.0       180. 180. 3582.34   TRC-97  1
5820-00-921-6566 SAB  1 0 08 02 0 .00008         6.00 0.00 0.00 6.00 0.00 0.00
5820-00-921-6566                180. 99.0       180. 180. 600.60    TRC-97  1
5820-00-921-6569 SAB  1 0 08 02 0 .00030         1400 .620 0.00 1400 .620 0.00
5820-00-921-6569                180. 99.0       180. 180. 291.53    TRC-97  1
5820-00-921-6570 SAB  1 0 08 02 0 .00001         5.00 0.00 0.00 5.00 0.00 0.00
5820-00-921-6570                180. 99.0       180. 180. 251.67    TRC-97  1
5820-00-921-6571 SAB  1 0 08 02 0 .00008         1100 0.00 0.00 1100 0.00 0.00
5820-00-921-6571                180. 99.0       180. 180. 334.75    TRC-97  1
5820-00-921-6574 SAB  1 0 08 02 0 .00032         1400 .320 0.00 1400 .320 0.00
5820-00-921-6574                180. 99.0       180. 180. 888.90    TRC-97  1
5820-00-921-6696 SAB  1 0 08 02 0 .00020         8.00 .170 0.00 8.00 .170 0.00
5820-00-921-6696                180. 99.0       180. 180. 754.00    TRC-97  1
5820-00-123-3954 SAB  1 0 06 02 0 .00033         1200 .600 0.00 1200 .600 0.00
5820-00-123-3954                180. 99.0       180. 180. 1903.00   TRC-87C 1
5820-00-252-2759 SAB  1 0 06 02 0 .00043         1200 .850 0.00 1200 .850 0.00
5820-00-252-2759                180. 99.0       180. 180. 1555.30   TRC-87C 1
5820-00-485-8881 SAB  1 0 09 03 0 .00020         9.00 .100 0.00 9.00 .100 0.00
5820-00-485-8881                180. 99.0       180. 180. 68.31     TRC-87C 1
5820-00-401-8061 SAB  1 0 09 03 0 .00043         1300 .470 0.00 1300 .470 0.00
5820-00-401-8061                180. 99.0       180. 180. 417.20    TRC-87  1
5820-00-416-8546 SAB  1 0 09 03 0 .00016         0.00 1.00 0.00 0.00 1.00 0.00
5820-00-416-8546                180. 99.0       180. 180. 1569.30   TRC-87  1
5820-00-416-8552 SAB  1 0 09 03 0 .00008         9.00 .670 0.00 9.00 .670 0.00
5820-00-416-8552                180. 99.0       180. 180. 216.30    TRC-87  1
5820-00-427-9429 SAB  1 0 09 03 0 .00008         0.00 1.00 0.00 0.00 1.00 0.00
5820-00-427-9429                180. 99.0       180. 180. 1256.60   TRC-87  1
5820-00-437-9952 SAB  1 0 06 02 0 .00004         1.00 .500 0.00 1.00 .500 0.00
5820-00-437-9952                180. 99.0       180. 180. 303.90    TRC-87  1
5820-00-491-4046 SAB  1 0 09 03 0 .00027         2.00 .310 0.00 2.00 .310 0.00
5820-00-491-4046                180. 99.0       180. 180. 275.01    TRC-87  1
5820-00-494-8815 SAB  1 0 09 03 0 .00052         8.00 .240 0.00 8.00 .310 0.00
5820-00-494-8815                180. 99.0       180. 180. 180.25    TRC-87  1
5815-00-050-0230 SAB  1 0 01 01 0 .00095         4.00 0.00 0.00 4.00 0.00 0.00
5815-00-050-0230                180 99.0        180. 180. 402.78    TGC-28C 1
5815-00-028-4324 SAB  1 0 01 01 0 .00016         1500 0.00 0.00 1500 0.00 0.00
5815-00-028-4324                180. 99.0       180. 180. 1396.80   TGC-28C 1
5815-00-489-6641 SAB  1 0 01 01 0 .00010         4.00 .330 0.00 4.00 .330 0.00
5815-00-489-6641                180. 99.0       180. 180. 1531.00   TGC-28C 1
5815-00-140-8604 SAB  1 0 01 01 0 .00008         8.00 0.00 0.00 8.00 0.00 0.00
5815-00-140-8604                180. 99.0       180. 180. 496.50    TGC-28C 1
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5815-00-489-6642 SAB  1 0 01 01 0 .00008        1.00 .500 0.00 1.00 .500 0.00
5815-00-489-6642                180. 99.0       180. 180. 1531.00  TGC-28  1
5895-00-450-8365 SAB  1 0 01 01 0 .00008        5.00 0.00 0.00 5.00 0.00 0.00
5895-00-450-8365                180. 99.0       180. 180. 350.00   TGC-28  1
5895-00-450-8366 SAB  1 0 01 01 0 .00023        4.00 0.00 0.00 4.00 0.00 0.00
5895-00-450-8366                180. 99.0       180. 180. 1462.00  TGC-28  1
5805-00-466-3086 SAB  1 0 01 01 0 .00004        1.00 0.00 0.00 1.00 0.00 0.00
5805-00-466-3086                180. 99.0       180. 180. 836.70   TGC-28  1
5805-00-488-4610 SAB  1 0 01 01 0 .00016        1500 0.00 0.00 1500 0.00 0.00
5805-00-488-4610                180. 99.0       180. 180. 1383.00  TGC-28  1
5814-01-114-6703 SAB  1 0 01 01 0 .00004        1400 0.00 0.00 1400 0.00 0.00
5814-01-114-6703                180. 99.0       180. 180. 1937.43  TGC-28  1
5805-00-999-5032 SAB  1 0 01 01 0 .00021        9.00 .200 0.00 9.00 .200 0.00
5805-00-999-5032                180. 99.0       180. 180. 80.40    TSC-53C 1
5820-00-167-7673 SAB  1 0 01 01 0 .00012        0.00 1.00 0.00 0.00 1.00 0.00
5820-00-167-7673                180. 99.0       180. 180. 4330.00  TSC-53  1
5820-00-167-7675 SAB  1 0 01 01 0 .00016        8.00 .500 0.00 8.00 .500 0.00
5820-00-167-7675                180. 99.0       180. 180. 1930.00  TSC-53  1
5820-00-226-5367 SAB  1 0 01 01 0 .00008        0.00 0.00 1.00 0.00 0.00 1.00
5820-00-226-5367                180. 99.0       180. 180. 174.00   TSC-53  1
5820-00-226-5368 SAB  1 0 01 01 0 .00008        0.00 1.00 0.00 0.00 1.00 0.00
5820-00-226-5368                180. 99.0       180. 180. 304.00   TSC-53  1
5820-00-226-5436 SAB  1 0 01 01 0 .00004        0.00 1.00 0.00 0.00 1.00 0.00
5820-00-226-5436                180. 99.0       180. 180. 525.00   TSC-53  1
5820-00-924-8465 SAB  1 0 01 01 0 .00025        1400 .670 0.00 1400 .670 0.00
5820-00-924-8465                180. 99.0       180. 180. 1278.00  TSC-53  1
5821-00-138-7991 SAB  1 0 01 01 0 .00016        1.00 0.00 0.00 1.00 0.00 0.00
5821-00-138-7991                180. 99.0       180. 180. 4729.00  TSC-53  1
5821-00-570-4232 SAB  1 0 01 01 0 .00033        3.00 .800 0.00 3.00 .800 0.00
5821-00-570-4232                180. 99.0       180. 180. 956.87   TSC-53  1
5821-00-576-4866 SAB  1 0 01 01 0 .00046        1300 .790 0.00 1300 .790 0.00
5821-00-576-4866                180. 99.0       180. 180. 1866.36  TSC-53  1
5945-00-991-8258 SAB  1 0 15 03 0 .00111        0.00 0.00 1.00 0.00 0.00 1.00
5945-00-991-8258                180. 99.0       180. 180. 70.21    TSC-60C 1
3030-00-482-8284 SAB  1 0 05 01 0 .00014        0.00 0.00 1.00 0.00 0.00 1.00
3030-00-482-8284                180. 99.0       180. 180. 3.24     TSC-60C 1
5820-00-005-1867 SAB  1 0 05 01 0 .00008        9.00 0.00 0.00 9.00 0.00 0.00
5820-00-005-1867                180. 99.0       180. 180. 1564.00  TSC-60  1
5820-00-005-8628 SAB  1 0 05 01 0 .00033        1.00 .700 0.00 1.00 .700 0.00
5820-00-005-8628                180. 99.0       180. 180. 20958.00 TSC-60  1
5820-00-006-1122 SAB  1 0 05 01 0 .00002        1.00 0.00 0.00 1.00 0.00 0.00
5820-00-006-1122                180. 99.0       180. 180. 6521.96  TSC-60  1
5820-00-006-1123 SAB  1 0 05 01 0 .00002        0.00 1.00 0.00 0.00 1.00 0.00
5820-00-006-1123                180. 99.0       180. 180. 10029.11 TSC-60  1
5820-00-260-0412 SAB  1 0 05 01 0 .00008        0.00 1.00 0.00 0.00 1.00 0.00
5820-00-260-0412                180. 99.0       180. 180. 2029.10  TSC-60  1
5820-00-409-2470 SAB  1 0 05 01 0 .00040        8.00 .630 0.00 8.00 .630 0.00
5820-00-409-2470                180. 99.0       180. 180. 11032.00 TSC-60  1
5820-00-492-9770 SAB  1 0 05 01 0 .00006        1.00 .670 0.00 1.00 .670 0.00
5820-00-492-9770                180. 99.0       180. 180. 2890.00  TSC-60  1
5820-00-492-9774 SAB  1 0 05 01 0 .00013        1100 .630 0.00 1100 .630 0.00
5820-00-492-9774                180. 99.0       180. 180. 4573.00  TSC-60  1
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VTM
5895-00-400-8106 1 1.0          1.0
5840-00-162-12 ' 1 1.0          1.0
5960-00-078-0684 1 1.0          1.0
5840-00-396-1208 1 1.0          1.0
5840-00-572-1617 1 1.0          1.0
5840-01-027-0315 1 1.0          1.0
5840-01-034-4607 1 1.0          1.0
5840-01-035-1166 1 1.0          1.0
5895-00-400-8104 1 1.0          1.0
5895-00-400-8108 1 1.0          1.0
5840-01-037-5526 1 1.0          1.0
5840-01-055-9558 1 1.0          1.0
6130-00-443-6963 1 1.0          1.0
6115-00-456-3904 1 1.0          1.0
6110-00-442-7513 1 1.0          1.0
6110-00-442-7488 1 1.0          1.0
6110-00-442-7478 1 1.0          1.0
2910-00-109-2539 1 1.0          1.0
6110-00-442-7469 1 1.0          1.0
6110-00-442-7477 1 1.0          1.0
5820-00-917-6578 1 1.0          1.0
5820-00-917-8303 1 1.0          1.0
5820-00-921-6562 1 1.0          1.0
5820-00-921-6565 1 1.0          1.0
5820-00-921-6566 1 1.0          1.0
5820-00-921-6569 1 1.0          1.0
5820-00-921-6570 1 1.0          1.0
5820-00-921-6571 1 1.0          1.0
5820-00-921-6574 1 1.0          1.0
5820-00-921-6696 1 1.0          1.0
5820-00-123-3954 1 1.0          1.0
5820-00-252-2759 1 1.0          1.0
5820-00-485-8881 1 1.0          1.0
5820-00-401-8061 1 1.0          1.0
5820-00-416-8546 1 1.0          1.0
5820-00-416-8552 1 1.0          1.0
5820-00-427-9429 1 1.0          1.0
5820-00-437-9952 1 1.0          1.0
5820-00-491-4046 1 1.0          1.0
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5820-00-494-8815 1 1.0          1.0
5815-00-050-0230 1 1.0          1.0
5815-00-028-4324 1 1.0          1.0
5815-00-489-6641 1 1.0          1.0
5815-00-140-8604 1 1.0          1.0
5815-00-489-6642 1 1.0          1.0
5895-00-450-8365 1 1.0          1.0
5895-00-450-8366 1 1.0          1.0
5805-00-466-3086 1 1.0          1.0
5805-00-488-4610 1 1.0          1.0
5814-01-114-6703 1 1.0          1.0
5805-00-999-5032 1 1.0          1.0
5820-00-167-7673 1 1.0          1.0
5820-00-167-7675 1 1.0          1.0
5820-00-226-5367 1 1.0          1.0
5820-00-226-5368 1 1.0          1.0
5820-00-226-5436 1 1.0          1.0
5820-00-924-8465 1 1.0          1.0
5821-00-138-7991 1 1.0          1.0
5821-00-570-4232 1 1.0          1.0
5821-00-576-4866 1 1.0          1.0
5945-00-991-8258 1 1.0          1.0
3030-00-482-8284 1 1.0          1.0
5820-00-005-1867 1 1.0          1.0
5820-00-005-8628 1 1.0          1.0
5820-00-006-1122 1 1.0          1.0
5820-00-006-1123 1 1.0          1.0
5820-00-260-0412 1 1.0          1.0
5820-00-409-2470 1 1.0          1.0
5820-00-492-9770 1 1.0          1.0
5820-00-492-9774 1 1.0          1.0
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The APPL and STK cards used in the Northern region were different from those used in the Southern region, and are shown below:

APPL

5895-00-400-8106	606C1.0	609C1.0	626F1.0	636F1.0	619F1.0	629F1.0
5840-00-162-1231	606C1.0	609C1.0	626F1.0	636F1.0	619F1.0	629F1.0
5960-00-078-0684	606C1.0	609C1.0	626F1.0	636F1.0	619F1.0	629F1.0
5840-00-396-1208	606C1.0	609C1.0	626F1.0	636F1.0	619F1.0	629F1.0
5840-00-572-1617	606C1.0	609C1.0	626F1.0	636F1.0	619F1.0	629F1.0
5840-01-027-0315	606C1.0	609C1.0	626F1.0	636F1.0	619F1.0	629F1.0
5840-01-034-4607	606C1.0	609C1.0	626F1.0	636F1.0	619F1.0	629F1.0
5840-01-035-1166	606C1.0	609C1.0	626F1.0	636F1.0	619F1.0	629F1.0
5895-00-400-8104	606C1.0	609C1.0	626F1.0	636F1.0	619F1.0	629F1.0
5895-00-400-8108	606C1.0	609C1.0	626F1.0	636F1.0	619F1.0	629F1.0
5840-01-037-5526	606C1.0	609C1.0	626F1.0	636F1.0	619F1.0	629F1.0
5840-01-055-9558	606C1.0	609C1.0	626F1.0	636F1.0	619F1.0	629F1.0
6130-00-443-6963	606C1.0	609C1.0	626F1.0	636F1.0	619F1.0	629F1.0
6115-00-456-3904	606C1.0	609C1.0	626F1.0	636F1.0	619F1.0	629F1.0
6110-00-442-7513	606C1.0	609C1.0	626F1.0	636F1.0	619F1.0	629F1.0
6110-00-442-7488	606C1.0	609C1.0	626F1.0	636F1.0	619F1.0	629F1.0
6110-00-442-7478	606C1.0	609C1.0	626F1.0	636F1.0	619F1.0	629F1.0
2910-00-109-2539	606C1.0	609C1.0	626F1.0	636F1.0	619F1.0	629F1.0
6110-00-442-7469	606C1.0	609C1.0	626F1.0	636F1.0	619F1.0	629F1.0
6110-00-442-7477	606C1.0	609C1.0	626F1.0	636F1.0	619F1.0	629F1.0
5820-00-917-6578	606C1.0	609C1.0	626F1.0	636F1.0	619F1.0	629F1.0
5820-00-917-8303	606C1.0	609C1.0	626F1.0	636F1.0	619F1.0	629F1.0
5820-00-921-6562	606C1.0	609C1.0	626F1.0	636F1.0	619F1.0	629F1.0
5820-00-921-6565	606C1.0	609C1.0	626F1.0	636F1.0	619F1.0	629F1.0
5820-00-921-6566	606C1.0	609C1.0	626F1.0	636F1.0	619F1.0	629F1.0
5820-00-921-6569	606C1.0	609C1.0	626F1.0	636F1.0	619F1.0	629F1.0
5820-00-921-6570	606C1.0	609C1.0	626F1.0	636F1.0	619F1.0	629F1.0
5820-00-921-6571	606C1.0	609C1.0	626F1.0	636F1.0	619F1.0	629F1.0
5820-00-921-6574	606C1.0	609C1.0	626F1.0	636F1.0	619F1.0	629F1.0
5820-00-921-6696	606C1.0	609C1.0	626F1.0	636F1.0	619F1.0	629F1.0
5820-00-123-3954	606C1.0	609C1.0	626F0.0	636F0.0	619F0.0	629F0.0
5820-00-252-2759	606C1.0	609C1.0	626F0.0	636F0.0	619F0.0	629F0.0
5820-00-485-8881	606C1.0	609C1.0	626F0.0	636F0.0	619F0.0	629F0.0
5820-00-401-8061	606C1.0	609C1.0	626F0.0	636F0.0	619F0.0	629F0.0
5820-00-416-8546	606C1.0	609C1.0	626F0.0	636F0.0	619F0.0	629F0.0
5820-00-416-8552	606C1.0	609C1.0	626F0.0	636F0.0	619F0.0	629F0.0
5820-00-427-9429	606C1.0	609C1.0	626F0.0	636F0.0	619F0.0	629F0.0
5820-00-437-9952	606C1.0	609C1.0	626F0.0	636F0.0	619F0.0	629F0.0
5820-00-491-4066	606C1.0	609C1.0	626F0.0	636F0.0	619F0.0	629F0.0
5820-00-494-8815	606C1.0	609C1.0	626F0.0	636F0.0	619F0.0	629F0.0
5815-00-050-0230	606C1.0	609C1.0	626F0.0	636F0.0	619F0.0	629F0.0
5815-00-028-4324	606C1.0	609C1.0	626F0.0	636F0.0	619F0.0	629F0.0
5815-00-489-6641	606C1.0	609C1.0	626F0.0	636F0.0	619F0.0	629F0.0
5815-00-140-8604	606C1.0	609C1.0	626F0.0	636F0.0	619F0.0	629F0.0
5815-00-489-6642	606C1.0	609C1.0	626F0.0	636F0.0	619F0.0	629F0.0
5895-00-450-8365	606C1.0	609C1.0	626F0.0	636F0.0	619F0.0	629F0.0
5895-00-450-8366	606C1.0	609C1.0	626F0.0	636F0.0	619F0.0	629F0.0
5805-00-466-3086	606C1.0	609C1.0	626F0.0	636F0.0	619F0.0	629F0.0
5805-00-488-4610	606C1.0	609C1.0	626F0.0	636F0.0	619F0.0	629F0.0
5814-01-114-6703	606C1.0	609C1.0	626F0.0	636F0.0	619F0.0	629F0.0
5805-00-999-5032	606C0.0	609C0.0	626F1.0	636F1.0	619F1.0	629F1.0
5820-00-167-7673	606C0.0	609C0.0	626F1.0	636F1.0	619F1.0	629F1.0
5820-00-167-7675	606C0.0	609C0.0	626F1.0	636F1.0	619F1.0	629F1.0
5820-00-226-5367	606C0.0	609C0.0	626F1.0	636F1.0	619F1.0	629F1.0
5820-00-226-5368	606C0.0	609C0.0	626F1.0	636F1.0	619F1.0	629F1.0
5820-00-226-5436	606C0.0	609C0.0	626F1.0	636F1.0	619F1.0	629F1.0
5820-00-924-8465	606C0.0	609C0.0	626F1.0	636F1.0	619F1.0	629F1.0
5821-00-138-7991	606C0.0	609C0.0	626F1.0	636F1.0	619F1.0	629F1.0
5821-00-570-4232	606C0.0	609C0.0	626F1.0	636F1.0	619F1.0	629F1.0
5821-00-576-4866	606C0.0	609C0.0	626F1.0	636F1.0	619F1.0	629F1.0
5945-00-991-8258	606C1.0	609C1.0	626F0.0	636F0.0	619F0.0	629F0.0
3030-00-482-8284	606C1.0	609C1.0	626F0.0	636F0.0	619F0.0	629F0.0
5820-00-005-1867	606C1.0	609C1.0	626F0.0	636F0.0	619F0.0	629F0.0
5820-00-005-8628	606C1.0	609C1.0	626F0.0	636F0.0	619F0.0	629F0.0
5820-00-006-1122	606C1.0	609C1.0	626F0.0	636F0.0	619F0.0	629F0.0
5820-00-006-1123	606C1.0	609C1.0	626F0.0	636F0.0	619F0.0	629F0.0
5820-00-260-0412	606C1.0	609C1.0	626F0.0	636F0.0	619F0.0	629F0.0
5820-00-409-2470	606C1.0	609C1.0	626F0.0	636F0.0	619F0.0	629F0.0
5820-00-492-9770	606C1.0	609C1.0	626F0.0	636F0.0	619F0.0	629F0.0
5820-00-492-9774	606C1.0	609C1.0	626F0.0	636F0.0	619F0.0	629F0.0

STK												
5895-00-400-8106	606C	1	609C	1	626F	1	636F	1	619F	1	629F	1
5895-00-400-8106	SAB	1	HOAS	1								
5840-00-162-1231	606C	1	609C	1	626F	1	636F	1	619F	1	629F	1
5840-00-162-1231	SAB	1	HOAS	1								
5960-00-078-0684	606C	1	609C	1	626F	1	636F	1	619F	1	629F	1
5960-00-078-0684	SAB	2	HOAS	1								
5840-00-396-1208	606C	1	609C	1	626F	1	636F	1	619F	1	629F	1
5840-00-396-1208	SAB	2	HOAS	1								
5840-00-572-1617	606C	1	609C	1	626F	1	636F	1	619F	1	629F	1
5840-00-572-1617	SAB	1	HOAS	1								
5840-01-027-0315	606C	1	609C	1	626F	1	636F	1	619F	1	629F	1
5840-01-027-0315	SAB	1	HOAS	1								
5840-01-034-4607	606C	1	609C	1	626F	1	636F	1	619F	1	629F	1
5840-01-034-4607	SAB	1	HOAS	1								
5840-01-035-1166	606C	1	609C	1	626F	1	636F	1	619F	1	629F	1
5840-01-035-1166	SAB	2	HOAS	1								
5895-00-400-8104	606C	1	609C	1	626F	1	636F	1	619F	1	629F	1
5895-00-400-8104	SAB	1	HOAS	1								
5895-00-400-8108	606C	1	609C	1	626F	1	636F	1	619F	1	629F	1
5895-00-400-8108	SAB	1	HOAS	1								
5840-01-037-5526	606C	1	609C	1	626F	0	636F	0	619F	0	629F	0
5840-01-037-5526	SAB	1	HOAS	1								
5840-01-055-9558	606C	1	609C	1	626F	1	636F	1	619F	1	629F	1
5840-01-055-9558	SAB	1	HOAS	1								
6130-00-443-6963	606C	4	609C	4	626F	3	636F	3	619F	3	629F	3
6130-00-443-6963	SAB	2	HOAS	1								
6115-00-456-3904	606C	4	609C	4	626F	3	636F	3	619F	3	629F	3
6115-00-456-3904	SAB	1	HOAS	1								
6110-00-442-7513	606C	4	609C	4	626F	4	636F	4	619F	4	629F	4
6110-00-442-7513	SAB	1	HOAS	1								
6110-00-442-7488	606C	4	609C	4	626F	4	636F	4	619F	4	629F	4
6110-00-442-7488	SAB	1	HOAS	1								
6110-00-442-7478	606C	5	609C	5	626F	4	636F	4	619F	4	629F	4
6110-00-442-7478	SAB	2	HOAS	2								
2910-00-109-2539	606C	5	609C	5	626F	4	636F	4	619F	4	629F	4
2910-00-109-2539	SAB	2	HOAS	2								
6110-00-442-7469	606C	4	609C	4	626F	4	636F	4	619F	4	629F	4
6110-00-442-7469	SAB	1	HOAS	1								
6110-00-442-7477	606C	5	609C	5	626F	4	636F	4	619F	4	629F	4
6110-00-442-7477	SAB	2	HOAS	2								
5820-00-917-6578	606C	2	609C	2	626F	2	636F	2	619F	2	629F	2
5820-00-917-6578	SAB	1	HOAS	1								
5820-00-917-8303	606C	2	609C	2	626F	2	636F	2	619F	2	629F	2
5820-00-917-8303	SAB	1	HOAS	1								
5820-00-921-6562	606C	2	609C	2	626F	2	636F	2	619F	2	629F	2
5820-00-921-6562	SAB	1	HOAS	1								
5820-00-921-6565	606C	2	609C	2	626F	2	636F	2	619F	2	629F	2
5820-00-921-6565	SAB	1	HOAS	1								
5820-00-921-6566	606C	2	609C	2	626F	2	636F	2	619F	2	629F	2
5820-00-921-6566	SAB	1	HOAS	1								
5820-00-921-6569	606C	2	609C	2	626F	2	636F	2	619F	2	629F	2
5820-00-921-6569	SAB	1	HOAS	1								
5820-00-921-6570	606C	2	609C	2	626F	2	636F	2	619F	2	629F	2
5820-00-921-6570	SAB	1	HOAS	1								
5820-00-921-6571	606C	2	609C	2	626F	2	636F	2	619F	2	629F	2
5820-00-921-6571	SAB	1	HOAS	1								
5820-00-921-6574	606C	2	609C	2	626F	2	636F	2	619F	2	629F	2
5820-00-921-6574	SAB	1	HOAS	1								
5820-00-921-6696	606C	2	609C	2	626F	2	636F	2	619F	2	629F	2
5820-00-921-6696	SAB	1	HOAS	1								
5820-00-123-3954	606C	2	609C	2	SAB	2	HOAS	2				
5820-00-252-2799	606C	2	609C	2	SAB	2	HOAS	2				
5820-00-485-8881	606C	2	609C	2	SAB	2	HOAS	2				
5820-00-401-8061	606C	2	609C	2	SAB	2	HOAS	2				
5820-00-416-8946	606C	2	609C	2	SAB	2	HOAS	2				

5820-00-416-8952	606C	2	609C	2	SAB	2	HOAS	2				
5820-00-427-9429	606C	2	609C	2	SAB	2	HOAS	2				
5820-00-437-9952	606C	2	609C	2	SAB	2	HOAS	2				
5820-00-491-4046	606C	2	609C	2	SAB	2	HOAS	2				
5820-00-494-8815	606C	2	609C	2	SAB	2	HOAS	2				
5815-00-050-0230	606C	2	609C	2	SAB	1	HOAS	1				
5815-00-028-4324	606C	2	609C	2	SAB	1	HOAS	1				
5815-00-489-6641	606C	2	609C	2	SAB	1	HOAS	1				
5815-00-140-8604	606C	2	609C	2	SAB	1	HOAS	1				
5815-00-489-6642	606C	2	609C	2	SAB	1	HOAS	1				
5895-00-450-8365	606C	2	609C	2	SAB	1	HOAS	1				
5895-00-450-8366	606C	2	609C	2	SAB	1	HOAS	1				
5805-00-466-3086	606C	2	609C	2	SAB	1	HOAS	1				
5805-00-488-4610	606C	2	609C	2	SAB	1	HOAS	1				
5814-01-116-6703	606C	2	609C	2	SAB	1	HOAS	1				
5805-00-999-5032	SAB	1	HOAS	1	626F	2	636F	2	619F	2	629F	2
5820-00-167-7673	SAB	1	HOAS	1	626F	2	636F	2	619F	2	629F	2
5820-00-167-7675	SAB	1	HOAS	1	626F	2	636F	2	619F	2	629F	2
5820-00-226-5367	SAB	1	HOAS	1	626F	2	636F	2	619F	2	629F	2
5820-00-226-5368	SAB	1	HOAS	1	626F	2	636F	2	619F	2	629F	2
5820-00-226-5436	SAB	1	HOAS	1	626F	2	636F	2	619F	2	629F	2
5820-00-924-8465	SAB	1	HOAS	1	626F	2	636F	2	619F	2	629F	2
5821-00-138-7991	SAB	1	HOAS	1	626F	2	636F	2	619F	2	629F	2
5821-00-570-4232	SAB	1	HOAS	1	626F	2	636F	2	619F	2	629F	2
5821-00-576-4866	SAB	1	HOAS	1	626F	2	636F	2	619F	2	629F	2
5945-00-991-8258	606C	10	609C	10	SAB	2	HOAS	2				
3030-00-682-8284	606C	5	609C	5	SAB	1	HOAS	1				
5820-00-005-1867	606C	2	609C	2	SAB	1	HOAS	1				
5820-00-005-8628	606C	2	609C	2	SAB	1	HOAS	1				
5820-00-006-1122	606C	2	609C	2	SAB	1	HOAS	1				
5820-00-006-1123	606C	2	609C	2	SAB	1	HOAS	1				
5820-00-260-0412	606C	2	609C	2	SAB	1	HOAS	1				
5820-00-409-2470	606C	2	609C	2	SAB	1	HOAS	1				
5820-00-492-9770	606C	2	609C	2	SAB	1	HOAS	1				
5820-00-492-9774	606C	2	609C	2	SAB	1	HOAS	1				

The following APPL and STK cards were used in scenario one for the Southern region (no FSL):

```
APPL
5895-00-400-8106 601C1.0  602C1.0  603C1.0
5895-00-400-8106 612F1.0  621F1.0  631F1.0  632F1.0  611F1.0  622F1.0
5840-00-162-1231 601C1.0  602C1.0  603C1.0
5840-00-162-1231 612F1.0  621F1.0  631F1.0  632F1.0  611F1.0  622F1.0
5960-00-078-0684 601C1.0  602C1.0  603C1.0
5960-00-078-0684 612F1.0  621F1.0  631F1.0  632F1.0  611F1.0  622F1.0
5840-00-396-1208 601C1.0  602C1.0  603C1.0
5840-00-396-1208 612F1.0  621F1.0  631F1.0  632F1.0  611F1.0  622F1.0
5840-00-572-1617 601C1.0  602C1.0  603C1.0
5840-00-572-1617 612F1.0  621F1.0  631F1.0  632F1.0  611F1.0  622F1.0
5840-01-027-0315 601C1.0  602C1.0  603C1.0
5840-01-027-0315 612F1.0  621F1.0  631F1.0  632F1.0  611F1.0  622F1.0
5840-01-034-4607 601C1.C  602C1.0  603C1.0
5840-01-034-4607 612F1.0  621F1.0  631F1.0  632F1.0  611F1.0  622F1.0
5840-01-035-1166 601C1.0  602C1.0  603C1.0
5840-01-035-1166 612F1.0  621F1.0  631F1.0  632F1.0  611F1.0  622F1.0
5895-00-400-8104 601C1.0  602C1.0  603C1.0
5895-00-400-8104 612F1.0  621F1.0  631F1.0  632F1.0  611F1.0  622F1.0
5895-00-400-8108 601C1.0  602C1.0  603C1.0
5895-00-400-8108 612F1.0  621F1.0  631F1.0  632F1.0  611F1.0  622F1.0
5840-01-037-5526 601C1.0  602C1.0  603C1.0
5840-01-032-5526 612F1.0  621F1.0  631F1.0  632F1.0  611F1.0  622F1.0
5840-01-055-9558 601C1.C  602C1.0  603C1.0
5840-01-055-9558 612F1.0  621F1.0  631F1.0  632F1.0  611F1.0  622F1.0
6130-00-443-6963 601C1.0  602C1.0  603C1.0
6130-00-443-6963 612F1.0  621F1.0  631F1.0  632F1.0  611F1.0  622F1.0
6115-00-456-3904 601C1.0  602C1.0  603C1.0
6115-00-456-3904 612F1.0  621F1.0  631F1.0  632F1.0  611F1.0  622F1.0
6110-00-442-7513 601C1.0  602C1.0  603C1.0
6110-00-442-7513 612F1.0  621F1.0  631F1.0  632F1.0  611F1.0  622F1.0
6110-00-442-7488 601C1.0  602C1.0  603C1.0
6110-00-422-7488 612F1.0  621F1.0  631F1.0  632F1.0  611F1.0  622F1.0
6110-00-442-7478 601C1.0  602C1.0  603C1.0
6110-00-442-7478 612F1.0  621F1.0  631F1.0  632F1.0  611F1.0  622F1.0
2910-00-109-2539 601C1.0  602C1.0  603C1.0
2910-00-109-2539 612F1.0  621F1.0  631F1.0  632F1.0  611F1.0  622F1.0
6110-00-442-7469 601C1.0  602C1.0  603C1.0
6110-00-442-7469 612F1.0  621F1.0  631F1.0  632F1.0  611F1.0  622F1.0
6110-00-442-7477 601C1.0  602C1.0  603C1.0
6110-00-442-7477 612F1.0  621F1.0  631F1.0  632F1.0  611F1.0  622F1.0
5820-00-917-6578 601C1.0  602C1.0  603C1.0
5820-00-917-6578 612F1.0  621F1.0  631F1.0  632F1.0  611F1.0  622F1.0
5820-00-917-8303 601C1.0  602C1.0  603C1.0
5820-00-917-8303 612F1.0  621F1.0  631F1.0  632F1.0  611F1.0  622F1.0
5820-00-921-6562 601C1.0  602C1.0  603C1.0
5820-00-921-6562 612F1.0  621F1.0  631F1.0  632F1.0  611F1.0  622F1.0
5820-00-921-6565 601C1.0  602C1.0  603C1.0
5820-00-921-6565 612F1.0  621F1.0  631F1.0  632F1.0  611F1.0  622F1.0
5820-00-921-6566 601C1.0  602C1.0  603C1.0
5820-00-921-6566 612F1.0  621F1.0  631F1.0  632F1.0  611F1.0  622F1.0
5820-00-921-6569 601C1.0  602C1.0  603C1.0
5820-00-921-6569 612F1.0  621F1.0  631F1.0  632F1.0  611F1.0  622F1.0
5820-00-921-6570 601C1.0  602C1.0  603C1.0
5820-00-921-6570 612F1.0  621F1.0  631F1.0  632F1.0  611F1.0  622F1.0
5820-00-921-6571 601C1.0  602C1.0  603C1.0
5820-00-921-6571 612F1.0  621F1.0  631F1.0  632F1.0  611F1.0  622F1.0
5820-00-921-6574 601C1.0  602C1.0  603C1.0
5820-00-921-6574 612F1.0  621F1.0  631F1.0  632F1.0  611F1.0  622F1.0
5820-00-921-6696 601C1.0  602C1.0  603C1.0
5820-00-921-6696 612F1.0  621F1.0  631F1.0  632F1.0  611F1.0  622F1.0
5820-00-123-3954 601C1.0  602C1.0  603C1.0
5820-00-123-3954 612F0.0  621F0.0  631F0.0  632F0.0  611F0.0  622F0.0
5820-00-252-2759 601C1.0  602C1.0  603C1.0
5820-00-252-2759 612F0.0  621F0.0  631F0.0  632F0.0  611F0.0  622F0.0
5820-00-485-8881 601C1.0  602C1.0  603C1.0
5820-00-485-8881 612F0.0  621F0.0  631F0.0  632F0.0  611F0.0  622F0.0
5820-00-401-8061 601C1.0  602C1.0  603C1.0
5820-00-401-8061 612F0.0  621F0.0  631F0.0  632F0.0  611F0.0  622F0.0
5820-00-416-8546 601C1.0  602C1.0  603C1.0
5820-00-416-8546 612F0.0  621F0.0  631F0.0  632F0.0  611F0.0  622F0.0
5820-00-416-8552 601C1.0  602C1.0  603C1.0
5820-00-416-8552 612F0.0  621F0.0  631F0.0  632F0.0  611F0.0  622F0.0
5820-00-427-9429 601C1.0  602C1.0  603C1.0
5820-00-427-9429 612F0.0  621F0.0  631F0.0  632F0.0  611F0.0  622F0.0
5820-00-437-9952 601C1.0  602C1.0  603C1.0
5820-00-437-9952 612F0.0  621F0.0  631F0.0  632F0.0  611F0.0  622F0.0
5820-00-491-4046 601C1.0  602C1.0  603C1.0
5820-00-491-4046 612F0.0  621F0.0  631F0.0  632F0.0  611F0.0  622F0.0
5820-00-494-8815 601C1.0  602C1.0  603C1.0
5820-00-494-8815 612F0.0  621F0.0  631F0.0  632F0.0  611F0.0  622F0.0
5815-00-050-0230 601C1.0  602C1.0  603C1.0
5815-00-050-0230 612F0.0  621F0.0  631F0.0  632F0.0  611F0.0  622F0.0
5815-00-028-4324 601C1.0  602C1.0  603C1.0
5815-00-028-4324 612F0.0  621F0.0  631F0.0  632F0.0  611F0.0  622F0.0
```

5815-00-489-6641	601C1.0	602C1.0	603C1.0			
5815-00-489-6641	612F0.0	621F0.0	631F0.0	632F0.0	611F0.0	622F0.0
5815-00-140-8604	601C1.0	602C1.0	603C1.0			
5815-00-140-8604	612F0.0	621F0.0	631F0.0	632F0.0	611F0.0	622F0.0
5815-00-489-6642	601C1.0	602C1.0	603C1.0			
5815-00-489-6642	612F0.0	621F0.0	631F0.0	632F0.0	611F0.0	622F0.0
5895-00-490-8365	601C1.0	602C1.0	603C1.0			
5895-00-490-8365	612F0.0	621F0.0	631F0.0	632F0.0	611F0.0	622F0.0
5895-00-490-8366	601C1.0	602C1.0	603C1.0			
5895-00-490-8366	612F0.0	621F0.0	631F0.0	632F0.0	611F0.0	622F0.0
5805-00-466-3086	601C1.0	602C1.0	603C1.0			
5805-00-466-3086	612F0.0	621F0.0	631F0.0	632F0.0	611F0.0	622F0.0
5805-00-488-4610	601C1.0	602C1.0	603C1.0			
5805-00-488-4610	612F0.0	621F0.0	631F0.0	632F0.0	611F0.0	622F0.0
5814-01-114-6703	601C1.0	602C1.0	603C1.0			
5814-01-114-6703	612F0.0	621F0.0	631F0.0	632F0.0	611F0.0	622F0.0
5805-00-999-5032	601C0.0	602C0.0	603C0.0			
5805-00-999-5032	612F1.0	621F1.0	631F1.0	632F1.0	611F1.0	622F1.0
5820-00-167-7673	601C0.0	602C0.0	603C0.0			
5820-00-167-7673	612F1.0	621F1.0	631F1.0	632F1.0	611F1.0	622F1.0
5820-00-167-7675	601C0.0	602C0.0	603C0.0			
5820-00-167-7675	612F1.0	621F1.0	631F1.0	632F1.0	611F1.0	622F1.0
5820-00-226-5367	601C0.0	602C0.0	603C0.0			
5820-00-226-5367	612F1.0	621F1.0	631F1.0	632F1.0	611F1.0	622F1.0
5820-00-226-5368	601C0.0	602C0.0	603C0.0			
5820-00-226-5368	612F1.0	621F1.0	631F1.0	632F1.0	611F1.0	622F1.0
5820-00-226-5436	601C0.0	602C0.0	603C0.0			
5820-00-226-5436	612F1.0	621F1.0	631F1.0	632F1.0	611F1.0	622F1.0
5820-00-924-8465	601C0.0	602C0.0	603C0.0			
5820-00-924-8465	612F1.0	621F1.0	631F1.0	632F1.0	611F1.0	622F1.0
5821-00-138-7991	601C0.0	602C0.0	603C0.0			
5821-00-138-7991	612F1.0	621F1.0	631F1.0	632F1.0	611F1.0	622F1.0
5821-00-570-4232	601C0.0	602C0.0	603C0.0			
5821-00-570-4232	612F1.0	621F1.0	631F1.0	632F1.0	611F1.0	622F1.0
5821-00-576-4866	601C0.0	602C0.0	603C0.0			
5821-00-576-4866	612F1.0	621F1.0	631F1.0	632F1.0	611F1.0	622F1.0
5945-00-991-8258	601C1.0	602C1.0	603C1.0			
5945-00-991-8258	612F0.0	621F0.0	631F0.0	632F0.0	611F0.0	622F0.0
3030-00-482-8284	601C1.0	602C1.0	603C1.0			
3030-00-482-8284	612F0.0	621F0.0	631F0.0	632F0.0	611F0.0	622F0.0
5820-00-005-1867	601C1.0	602C1.0	603C1.0			
5820-00-005-1867	612F0.0	621F0.0	631F0.0	632F0.0	611F0.0	622F0.0
5820-00-005-8628	601C1.0	602C1.0	603C1.0			
5820-00-005-8628	612F0.0	621F0.0	631F0.0	632F0.0	611F0.0	622F0.0
5820-00-006-1122	601C1.0	602C1.0	603C1.0			
5820-00-006-1122	612F0.0	621F0.0	631F0.0	622F0.0	611F0.0	622F0.0
5820-00-006-1123	601C1.0	602C1.0	603C1.0			
5820-00-006-1123	612F0.0	621F0.0	631F0.0	632F0.0	611F0.0	622F0.0
5820-00-260-0412	601C1.0	602C1.0	603C1.0			
5820-00-260-0412	612F0.0	621F0.0	631F0.0	632F0.0	611F0.0	622F0.0
5820-00-409-2470	601C1.0	602C1.0	603C1.0			
5820-00-409-2470	612F0.0	621F0.0	631F0.0	632F0.0	611F0.0	622F0.0
5820-00-492-9770	601C1.0	602C1.0	603C1.0			
5820-00-492-9770	612F0.0	621F0.0	631F0.0	632F0.0	611F0.0	622F0.0
5820-00-492-9774	601C1.0	602C1.0	603C1.0			
5820-00-492-9774	612F0.0	621F0.0	631F0.0	632F0.0	611F0.0	622F0.0

STK

5895-00-400-8106	601C	1	602C	1	603C	1	SAB	1				
5895-00-400-8106	612F	1	621F	1	631F	1	632F	1	611F	1	622F	1
5840-00-162-1231	601C	1	602C	1	603C	1	SAB	1				
5840-00-162-1231	612F	1	621F	1	631F	1	632F	1	611F	1	622F	1
5960-00-078-0684	601C	1	602C	1	603C	1	SAB	2				
5960-00-078-0684	612F	1	621F	1	631F	1	632F	1	611F	1	622F	1
5840-00-396-1208	601C	1	602C	1	603C	1	SAB	2				
5840-00-396-1208	612F	1	621F	1	631F	1	632F	1	611F	1	622F	1
5840-00-572-1617	601C	1	602C	1	603C	1	SAB	1				
5840-00-572-1617	612F	1	621F	1	631F	1	632F	1	611F	1	622F	1
5840-01-027-0315	601C	1	602C	1	603C	1	SAB	1				
5840-01-027-0315	612F	1	621F	1	631F	1	632F	1	611F	1	622F	1
5840-01-034-4607	601C	1	602C	1	603C	1	SAB	1				
5840-01-034-4607	612F	1	621F	1	631F	1	632F	1	611F	1	622F	1
5840-01-035-1166	601C	1	602C	1	603C	1	SAB	2				
5840-01-035-1166	612F	1	621F	1	631F	1	632F	1	611F	1	622F	1
5895-00-400-8104	601C	1	602C	1	603C	1	SAB	1				
5895-00-400-8104	612F	1	621F	1	631F	1	632F	1	611F	1	622F	1
5895-00-400-8108	601C	1	602C	1	603C	1	SAB	1				
5895-00-400-8108	612F	1	621F	1	631F	1	632F	1	611F	1	622F	1
5840-01-037-9526	601C	1	602C	1	603C	1	SAB	1				
5840-01-055-9558	601C	1	602C	1	603C	1	SAB	1				
5840-01-055-9558	612F	1	621F	1	631F	1	632F	1	611F	1	612F	1
6130-00-443-6963	601C	4	602C	4	603C	4	SAB	2				
6130-00-443-6963	612F	3	621F	3	631F	3	632F	3	611F	3	622F	3
6115-00-456-3904	601C	4	602C	4	603C	4	SAB	1				
6115-00-456-3904	612F	3	621F	3	631F	3	632F	3	611F	3	622F	3
6110-00-442-7513	601C	4	602C	4	603C	4	SAB	1				
6110-00-442-7513	612F	4	621F	4	631F	4	632F	4	611F	4	622F	4
6110-00-442-7488	601C	4	602C	4	603C	4	SAB	1				
6110-00-442-7488	612F	4	621F	4	631F	4	632F	4	611F	4	622F	4
6110-00-442-7478	601C	5	602C	5	603C	5	SAB	2				
6110-00-442-7478	612F	4	621F	4	631F	4	632F	4	611F	4	622F	4

2910-00-109-2539	601C	5	602C	5	603C	5	SAB	2				
2910-00-109-2539	612F	4	621F	4	631F	4	632F	4	611F	4	622F	4
6110-00-442-7469	601C	4	602C	4	603C	4	SAB	1				
6110-00-442-7469	612F	4	621F	4	631F	4	632F	4	611F	4	622F	4
6110-00-442-7477	601C	5	602C	5	603C	5	SAB	2				
6110-00-442-7477	612F	4	621F	4	631F	4	632F	4	611F	4	622F	4
5820-00-917-6578	601C	2	602C	2	603C	2	SAB	1				
5820-00-917-6578	612F	2	621F	2	631F	2	632F	2	611F	2	622F	2
5820-00-917-8303	601C	2	602C	2	603C	2	SAB	1				
5820-00-917-8303	612F	2	621F	2	631F	2	632F	2	611F	2	622F	2
5820-00-921-6562	601C	2	602C	2	603C	2	SAB	1				
5820-00-921-6562	612F	2	621F	2	631F	2	632F	2	611F	2	622F	2
5820-00-921-6565	601C	2	602C	2	603C	2	SAB	1				
5820-00-921-6565	612F	2	621F	2	631F	2	632F	2	611F	2	622F	2
5820-00-921-6566	601C	2	602C	2	603C	2	SAB	1				
5820-00-921-6566	612F	2	621F	2	631F	2	632F	2	611F	2	622F	2
5820-00-921-6569	601C	2	602C	2	603C	2	SAB	1				
5820-00-921-6569	612F	2	621F	2	631F	2	632F	2	611F	2	622F	2
5820-00-921-6570	601C	2	602C	2	603C	2	SAB	1				
5820-00-921-6570	612F	2	621F	2	631F	2	632F	2	611F	2	622F	2
5820-00-921-6571	601C	2	602C	2	603C	2	SAB	1				
5820-00-921-6571	612F	2	621F	2	631F	2	632F	2	611F	2	622F	2
5820-00-921-6574	601C	2	602C	2	603C	2	SAB	1				
5820-00-921-6574	612F	2	621F	2	631F	2	632F	2	611F	2	622F	2
5820-00-921-6696	601C	2	602C	2	603C	2	SAB	1				
5820-00-921-6696	612F	2	621F	2	631F	2	632F	2	611F	2	622F	2
5820-00-123-3954	601C	2	602C	2	603C	2	SAB	2				
5820-00-252-2759	601C	2	602C	2	603C	2	SAB	2				
5820-00-485-8881	601C	2	602C	2	603C	2	SAB	2				
5820-00-401-8061	601C	2	602C	2	603C	2	SAB	2				
5820-00-416-8546	601C	2	602C	2	603C	2	SAB	2				
5820-00-416-8552	601C	2	602C	2	603C	2	SAB	2				
5820-00-427-9429	601C	2	602C	2	603C	2	SAB	2				
5820-00-437-9952	601C	2	602C	2	603C	2	SAB	2				
5820-00-491-4046	601C	2	602C	2	603C	2	SAB	2				
5820-00-494-8815	601C	2	602C	2	603C	2	SAB	2				
5815-00-050-0230	601C	2	602C	2	603C	2	SAB	1				
5815-00-028-4324	601C	2	602C	2	603C	2	SAB	1				
5815-00-489-6641	601C	2	602C	2	603C	2	SAB	1				
5815-00-140-8604	601C	2	602C	2	603C	2	SAB	1				
5815-00-489-6642	601C	2	602C	2	603C	2	SAB	1				
5895-00-450-8365	601C	2	602C	2	603C	2	SAB	1				
5895-00-450-8366	601C	2	602C	2	603C	2	SAB	1				
5805-00-466-3086	601C	2	602C	2	603C	2	SAB	1				
5805-00-488-4610	601C	2	602C	2	603C	2	SAB	1				
5814-01-114-6703	601C	2	602C	2	603C	2	SAB	1				
5805-00-999-5032	612F	2	621F	2	631F	2	632F	2	611F	2	622F	2
5805-00-999-5032	SAB	1										
5820-00-167-7673	612F	2	621F	2	631F	2	632F	2	611F	2	622F	2
5820-00-167-7673	SAB	1										
5820-00-167-7675	612F	2	621F	2	631F	2	632F	2	611F	2	622F	2
5820-00-167-7675	SAB	1										
5820-00-226-5367	612F	2	621F	2	631F	2	632F	2	611F	2	622F	2
5820-00-226-5367	SAB	1										
5820-00-226-5368	612F	2	621F	2	631F	2	632F	2	611F	2	622F	2
5820-00-226-5368	SAB	1										
5820-00-226-5436	612F	2	621F	2	631F	2	632F	2	611F	2	622F	2
5820-00-226-5436	SAB	1										
5820-00-924-8465	612F	2	621F	2	631F	2	632F	2	611F	2	622F	2
5820-00-924-8465	SAB	1										
5821-00-138-7991	612F	2	621F	2	631F	2	632F	2	611F	2	622F	2
5821-00-138-7991	SAB	1										
5821-00-570-4232	612F	2	621F	2	631F	2	632F	2	611F	2	622F	2
5821-00-570-4232	SAB	1										
5821-00-576-4866	612F	2	621F	2	631F	2	632F	2	611F	2	622F	2
5821-00-576-4866	SAB	1										
5945-00-991-8258	601C	10	602C	10	603C	10	SAB	2				
3030-00-482-8284	601C	5	602C	5	603C	5	SAB	1				
5820-00-005-1867	601C	2	602C	2	603C	2	SAB	1				
5820-00-005-8628	601C	2	602C	2	603C	2	SAB	1				
5820-00-006-1122	601C	2	602C	2	603C	2	SAB	1				
5820-00-006-1123	601C	2	602C	2	603C	2	SAB	1				
5820-00-260-0412	601C	2	602C	2	603C	2	SAB	1				
5820-00-409-2470	601C	2	602C	2	603C	2	SAB	1				
5820-00-492-9770	601C	2	602C	2	603C	2	SAB	1				
5820-00-492-9774	601C	2	602C	2	603C	2	SAB	1				

The following APPL and STK inputs were used in scenario two for the Southern region (FSL added):

```
APPL
5895-00-400-8106 601C1.0   602C1.0   603C1.0
5895-00-400-8106 612F1.0   621F1.0   631F1.0   632F1.0   611F1.0   622F1.0
5840-00-162-1231 601C1.0   602C1.0   603C1.0
5840-00-162-1231 612F1.0   621F1.0   631F1.0   632F1.0   611F1.0   622F1.0
5960-00-078-0684 601C1.0   602C1.0   603C1.0
5960-00-078-0684 612F1.0   621F1.0   631F1.0   632F1.0   611F1.0   622F1.0
5840-00-396-1208 601C1.0   602C1.0   603C1.0
5840-00-396-1208 612F1.0   621F1.0   631F1.0   632F1.0   611F1.0   622F1.0
5840-00-572-1617 601C1.0   602C1.0   603C1.0
5840-00-572-1617 612F1.0   621F1.0   631F1.0   632F1.0   611F1.0   622F1.0
5840-01-027-0315 601C1.0   602C1.0   603C1.0
5840-01-027-0315 612F1.0   621F1.0   631F1.0   632F1.0   611F1.0   622F1.0
5840-01-034-4607 601C1.0   602C1.0   603C1.0
5840-01-034-4607 612F1.0   621F1.0   631F1.0   632F1.0   611F1.0   622F1.0
5840-01-035-1166 601C1.0   602C1.0   603C1.0
5840-01-035-1166 612F1.0   621F1.0   631F1.0   632F1.0   611F1.0   622F1.0
5895-00-400-8104 601C1.0   602C1.0   603C1.0
5895-00-400-8104 612F1.0   621F1.0   631F1.0   632F1.0   611F1.0   622F1.0
5895-00-400-8108 601C1.0   602C1.0   603C1.0
5895-00-400-8108 612F1.0   621F1.0   631F1.0   632F1.0   611F1.0   622F1.0
5840-01-037-5526 601C1.0   602C1.0   603C1.0
5840-01-032-5526 612F1.0   621F1.0   631F1.0   632F1.0   611F1.0   622F1.0
5840-01-055-9558 601C1.0   602C1.0   603C1.0
5840-01-055-9558 612F1.0   621F1.0   631F1.0   632F1.0   611F1.0   622F1.0
6130-00-443-6963 601C1.0   602C1.0   603C1.0
6130-00-443-6963 612F1.0   621F1.0   631F1.0   632F1.0   611F1.0   622F1.0
6115-00-456-3904 601C1.0   602C1.0   603C1.0
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6110-00-442-7513 601C1.0   602C1.0   603C1.0
6110-00-442-7513 612F1.0   621F1.0   631F1.0   632F1.0   611F1.0   622F1.0
6110-00-442-7488 601C1.0   602C1.0   603C1.0
6110-00-422-7488 612F1.0   621F1.0   631F1.0   632F1.0   611F1.0   622F1.0
6110-00-442-7478 601C1.0   602C1.0   603C1.0
6110-00-442-7478 612F1.0   621F1.0   631F1.0   632F1.0   611F1.0   622F1.0
2910-00-109-2539 601C1.0   602C1.0   603C1.0
2910-00-109-2539 612F1.0   621F1.0   631F1.0   632F1.0   611F1.0   622F1.0
6110-00-442-7469 601C1.0   602C1.0   603C1.0
6110-00-442-7469 612F1.0   621F1.0   631F1.0   632F1.0   611F1.0   622F1.0
6110-00-442-7477 601C1.0   602C1.0   603C1.0
6110-00-442-7477 612F1.0   621F1.0   631F1.0   632F1.0   611F1.0   622F1.0
5820-00-917-6578 601C1.0   602C1.0   603C1.0
5820-00-917-6578 612F1.0   621F1.0   631F1.0   632F1.0   611F1.0   622F1.0
5820-00-917-8303 601C1.0   602C1.0   603C1.0
5820-00-917-8303 612F1.0   621F1.0   631F1.0   632F1.0   611F1.0   622F1.0
5820-00-921-6562 601C1.0   602C1.0   603C1.0
5820-00-921-6562 612F1.0   621F1.0   631F1.0   632F1.0   611F1.0   622F1.0
5820-00-921-6565 601C1.0   602C1.0   603C1.0
5820-00-921-6565 612F1.0   621F1.0   631F1.0   632F1.0   611F1.0   622F1.0
5820-00-921-6566 601C1.0   602C1.0   603C1.0
5820-00-921-6566 612F1.0   621F1.0   631F1.0   632F1.0   611F1.0   622F1.0
5820-00-921-6569 601C1.0   602C1.0   603C1.0
5820-00-921-6569 612F1.0   621F1.0   631F1.0   632F1.0   611F1.0   622F1.0
5820-00-921-6570 601C1.0   602C1.0   603C1.0
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5820-00-921-6571 601C1.0   602C1.0   603C1.0
5820-00-921-6571 612F1.0   621F1.0   631F1.0   632F1.0   611F1.0   622F1.0
5820-00-921-6574 601C1.0   602C1.0   603C1.0
5820-00-921-6574 612F1.0   621F1.0   631F1.0   632F1.0   611F1.0   622F1.0
5820-00-921-6696 601C1.0   602C1.0   603C1.0
5820-00-921-6696 612F1.0   621F1.0   631F1.0   632F1.0   611F1.0   622F1.0
5820-00-123-3954 601C1.0   602C1.0   603C1.0
5820-00-123-3954 612F0.0   621F0.0   631F0.0   632F0.0   611F0.0   622F0.0
5820-00-252-2759 601C1.0   602C1.0   603C1.0
5820-00-252-2759 612F0.0   621F0.0   631F0.0   632F0.0   611F0.0   622F0.0
5820-00-485-8881 601C1.0   602C1.0   603C1.0
5820-00-485-8881 612F0.0   621F0.0   631F0.0   632F0.0   611F0.0   622F0.0
5820-00-401-8061 601C1.0   602C1.0   603C1.0
5820-00-401-8061 612F0.0   621F0.0   631F0.0   632F0.0   611F0.0   622F0.0
5820-00-416-8546 601C1.0   602C1.0   603C1.0
5820-00-416-8546 612F0.0   621F0.0   631F0.0   632F0.0   611F0.0   622F0.0
5820-00-416-8552 601C1.0   602C1.0   603C1.0
5820-00-416-8552 612F0.0   621F0.0   631F0.0   632F0.0   611F0.0   622F0.0
5820-00-427-9429 601C1.0   602C1.0   603C1.0
5820-00-427-9429 612F0.0   621F0.0   631F0.0   632F0.0   611F0.0   622F0.0
5820-00-437-9952 601C1.0   602C1.0   603C1.0
5820-00-437-9952 612F0.0   621F0.0   631F0.0   632F0.0   611F0.0   622F0.0
5820-00-491-4046 601C1.0   602C1.0   603C1.0
5820-00-491-4046 612F0.0   621F0.0   631F0.0   632F0.0   611F0.0   622F0.0
5820-00-494-8815 601C1.0   602C1.0   603C1.0
5820-00-494-8815 612F0.0   621F0.0   631F0.0   632F0.0   611F0.0   622F0.0
5815-00-050-0230 601C1.0   602C1.0   603C1.0
5815-00-050-0230 612F0.0   621F0.0   631F0.0   632F0.0   611F0.0   622F0.0
5815-00-028-4324 601C1.0   602C1.0   603C1.0
5815-00-028-4324 612F0.0   621F0.0   631F0.0   632F0.0   611F0.0   622F0.0
5815-00-489-6641 601C1.0   602C1.0   603C1.0
5815-00-489-6641 612F0.0   621F0.0   631F0.0   632F0.0   611F0.0   622F0.0
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5815-00-140-8604	601C1.0	602C1.0	603C1.0			
5815-00-140-8604	612F0.0	621F0.0	631F0.0	632F0.0	611F0.0	622F0.0
5815-00-489-6642	601C1.0	602C1.0	603C1.0			
5815-00-489-6642	612F0.0	621F0.0	631F0.0	632F0.0	611F0.0	622F0.0
5895-00-450-8365	601C1.0	602C1.0	603C1.0			
5895-00-450-8365	612F0.0	621F0.0	631F0.0	632F0.0	611F0.0	622F0.0
5895-00-450-8366	601C1.0	602C1.0	603C1.0			
5895-00-450-8366	612F0.0	621F0.0	631F0.0	632F0.0	611F0.0	622F0.0
5805-00-466-3086	601C1.0	602C1.0	603C1.0			
5805-00-466-3086	612F0.0	621F0.0	631F0.0	632F0.0	611F0.0	622F0.0
5805-00-488-4610	601C1.0	602C1.0	603C1.0			
5805-00-488-4610	612F0.0	621F0.0	631F0.0	632F0.0	611F0.0	622F0.0
5814-01-114-6703	601C1.0	602C1.0	603C1.0			
5814-01-114-6703	612F0.0	621F0.0	631F0.0	632F0.0	611F0.0	622F0.0
5805-00-999-5032	601C0.0	602C0.0	603C0.0			
5805-00-999-5032	612F1.0	621F1.0	631F1.0	632F1.0	611F1.0	622F1.0
5820-00-167-7673	601C0.0	602C0.0	603C0.0			
5820-00-167-7673	612F1.0	621F1.0	631F1.0	632F1.0	611F1.0	622F1.0
5820-00-167-7675	601C0.0	602C0.0	603C0.0			
5820-00-167-7675	612F1.0	621F1.0	631F1.0	632F1.0	611F1.0	622F1.0
5820-00-226-5367	601C0.0	602C0.0	603C0.0			
5820-00-226-5367	612F1.0	621F1.0	631F1.0	632F1.0	611F1.0	622F1.0
5820-00-226-5368	601C0.0	602C0.0	603C0.0			
5820-00-226-5368	612F1.0	621F1.0	631F1.0	632F1.0	611F1.0	622F1.0
5820-00-226-5436	601C0.0	602C0.0	603C0.0			
5820-00-226-5436	612F1.0	621F1.0	631F1.0	632F1.0	611F1.0	622F1.0
5820-00-924-8465	601C0.0	602C0.0	603C0.0			
5820-00-924-8465	612F1.0	621F1.0	631F1.0	632F1.0	611F1.0	622F1.0
5821-00-138-7991	601C0.0	602C0.0	603C0.0			
5821-00-138-7991	612F1.0	621F1.0	631F1.0	632F1.0	611F1.0	622F1.0
5821-00-570-4232	601C0.0	602C0.0	603C0.0			
5821-00-570-4232	612F1.0	621F1.0	631F1.0	632F1.0	611F1.0	622F1.0
5821-00-576-4866	601C0.0	602C0.0	603C0.0			
5821-00-576-4866	612F1.0	621F1.0	631F1.0	632F1.0	611F1.0	622F1.0
5945-00-991-8258	601C1.0	602C1.0	603C1.0			
5945-00-991-8258	612F0.0	621F0.0	631F0.0	632F0.0	611F0.0	622F0.0
3030-00-482-8284	601C1.0	602C1.0	603C1.0			
3030-00-482-8284	612F0.0	621F0.0	631F0.0	632F0.0	611F0.0	622F0.0
5820-00-005-1867	601C1.0	602C1.0	603C1.0			
5820-00-005-1867	612F0.0	621F0.0	631F0.0	632F0.0	611F0.0	622F0.0
5820-00-005-8628	601C1.0	602C1.0	603C1.0			
5820-00-005-8628	612F0.0	621F0.0	631F0.0	632F0.0	611F0.0	622F0.0
5820-00-006-1122	601C1.0	602C1.0	603C1.0			
5820-00-006-1122	612F0.0	621F0.0	631F0.0	632F0.0	611F0.0	622F0.0
5820-00-006-1123	601C1.0	602C1.0	603C1.0			
5820-00-006-1123	612F0.0	621F0.0	631F0.0	632F0.0	611F0.0	622F0.0
5820-00-260-0412	601C1.0	602C1.0	603C1.0			
5820-00-260-0412	612F0.0	621F0.0	631F0.0	632F0.0	611F0.0	622F0.0
5820-00-409-2470	601C1.0	602C1.0	603C1.0			
5820-00-409-2470	612F0.0	621F0.0	631F0.0	632F0.0	611F0.0	622F0.0
5820-00-492-9770	601C1.0	602C1.0	603C1.0			
5820-00-492-9770	612F0.0	621F0.0	631F0.0	632F0.0	611F0.0	622F0.0
5820-00-492-9774	601C1.0	602C1.0	603C1.0			
5820-00-492-9774	612F0.0	621F0.0	631F0.0	632F0.0	611F0.0	622F0.0

STK												
5895-00-400-8106	601C	1	602C	1	603C	1	SAB	1	SUAS	1		
5895-00-400-8106	612F	1	621F	1	631F	1	632F	1	611F	1	622F	1
5840-00-162-1231	601C	1	602C	1	603C	1	SAB	1	SUAS	1		
5840-00-162-1231	612F	1	621F	1	631F	1	632F	1	611F	1	622F	1
5960-00-078-0684	601C	1	602C	1	603C	1	SAB	2	SUAS	1		
5960-00-078-0684	612F	1	621F	1	631F	1	632F	1	611F	1	622F	1
5840-00-396-1208	601C	1	602C	1	603C	1	SAB	2	SUAS	1		
5840-00-396-1208	612F	1	621F	1	631F	1	632F	1	611F	1	622F	1
5840-00-572-1617	601C	1	602C	1	603C	1	SAB	1	SUAS	1		
5840-00-572-1617	612F	1	621F	1	631F	1	632F	1	611F	1	622F	1
5840-01-027-0315	601C	1	602C	1	603C	1	SAB	1	SUAS	1		
5840-01-027-0315	612F	1	621F	1	631F	1	632F	1	611F	1	622F	1
5840-01-034-4607	601C	1	602C	1	603C	1	SAB	1	SUAS	1		
5840-01-034-4607	612F	1	621F	1	631F	1	632F	1	611F	1	622F	1
5840-01-035-1166	601C	1	602C	1	603C	1	SAB	2	SUAS	1		
5840-01-035-1166	612F	1	621F	1	631F	1	632F	1	611F	1	622F	1
5895-00-400-8104	601C	1	602C	1	603C	1	SAB	1	SUAS	1		
5895-00-400-8104	612F	1	621F	1	631F	1	632F	1	611F	1	622F	1
5895-00-400-8108	601C	1	602C	1	603C	1	SAB	1	SUAS	1		
5895-00-400-8108	612F	1	621F	1	631F	1	632F	1	611F	1	622F	1
5840-01-037-5526	601C	1	602C	1	603C	1	SAB	1	SUAS	1		
5840-01-055-9558	601C	1	602C	1	603C	1	SAB	1	SUAS	1		
5840-01-055-9558	612F	1	621F	1	631F	1	632F	1	611F	1	612F	1
6130-00-443-6963	601C	4	602C	4	603C	4	SAB	2	SUAS	1		
6130-00-443-6963	612F	3	621F	3	631F	3	632F	3	611F	3	622F	3
6115-00-456-3904	601C	4	602C	4	603C	4	SAB	1	SUAS	1		
6115-00-456-3904	612F	3	621F	3	631F	3	632F	3	611F	3	622F	3
6110-00-442-7513	601C	4	602C	4	603C	4	SAB	1	SUAS	1		
6110-00-442-7513	612F	4	621F	4	631F	4	632F	4	611F	4	622F	4
6110-00-442-7488	601C	4	602C	4	603C	4	SAB	1	SUAS	1		
6110-00-442-7488	612F	4	621F	4	631F	4	632F	4	611F	4	622F	4
6110-00-442-7478	601C	5	602C	5	603C	5	SAB	2	SUAS	1		
6110-00-442-7478	612F	4	621F	4	631F	4	632F	4	611F	4	622F	4
2910-00-109-2539	601C	5	602C	5	603C	5	SAB	2	SUAS	1		
2910-00-109-2539	612F	4	621F	4	631F	4	632F	4	611F	4	622F	4

6110-00-442-7469	601C	4	602C	4	603C	4	SAB	1	SUAS	1		
6110-00-442-7469	612F	4	621F	4	631F	4	632F	4	611F	4	622F	4
6110-00-442-7477	601C	5	602C	5	603C	5	SAB	2	SUAS	1		
6110-00-442-7477	612F	4	621F	4	631F	4	632F	4	611F	4	622F	4
5820-00-917-6578	601C	2	602C	2	603C	2	SAB	1	SUAS	1		
5820-00-917-6578	612F	2	621F	2	631F	2	632F	2	611F	2	622F	2
5820-00-917-8303	601C	2	602C	2	603C	2	SAB	1	SUAS	1		
5820-00-917-8303	612F	2	621F	2	631F	2	632F	2	611F	2	622F	2
5820-00-921-6562	601C	2	602C	2	603C	2	SAB	1	SUAS	1		
5820-00-921-6562	612F	2	621F	2	631F	2	632F	2	611F	2	622F	2
5820-00-921-6565	601C	2	602C	2	603C	2	SAB	1	SUAS	1		
5820-00-921-6565	612F	2	621F	2	631F	2	632F	2	611F	2	622F	2
5820-00-921-6566	601C	2	602C	2	603C	2	SAB	1	SUAS	1		
5820-00-921-6566	612F	2	621F	2	631F	2	632F	2	611F	2	622F	2
5820-00-921-6569	601C	2	602C	2	603C	2	SAB	1	SUAS	1		
5820-00-921-6569	612F	2	621F	2	631F	2	632F	2	611F	2	622F	2
5820-00-921-6570	601C	2	602C	2	603C	2	SAB	1	SUAS	1		
5820-00-921-6570	612F	2	621F	2	631F	2	632F	2	611F	2	622F	2
5820-00-921-6571	601C	2	602C	2	603C	2	SAB	1	SUAS	1		
5820-00-921-6571	612F	2	621F	2	631F	2	632F	2	611F	2	622F	2
5820-00-921-6574	601C	2	602C	2	603C	2	SAB	1	SUAS	1		
5820-00-921-6574	612F	2	621F	2	631F	2	632F	2	611F	2	622F	2
5820-00-921-6696	601C	2	602C	2	603C	2	SAB	1	SUAS	1		
5820-00-921-6696	612F	2	621F	2	631F	2	632F	2	611F	2	622F	2
5820-00-123-3954	601C	2	602C	2	603C	2	SAB	2	SUAS	1		
5820-00-252-2759	601C	2	602C	2	603C	2	SAB	2	SUAS	1		
5820-00-485-8881	601C	2	602C	2	603C	2	SAB	2	SUAS	1		
5820-00-401-8061	601C	2	602C	2	603C	2	SAB	2	SUAS	1		
5820-00-416-8546	601C	2	602C	2	603C	2	SAB	2	SUAS	1		
5820-00-416-8552	601C	2	602C	2	603C	2	SAB	2	SUAS	1		
5820-00-427-9429	601C	2	602C	2	603C	2	SAB	2	SUAS	1		
5820-00-437-9952	601C	2	602C	2	603C	2	SAB	2	SUAS	1		
5820-00-491-4046	601C	2	602C	2	603C	2	SAB	2	SUAS	1		
5820-00-494-8815	601C	2	602C	2	603C	2	SAB	2	SUAS	1		
5815-00-050-0230	601C	2	602C	2	603C	2	SAB	1	SUAS	1		
5815-00-028-4324	601C	2	602C	2	603C	2	SAB	1	SUAS	1		
5815-00-489-6641	601C	2	602C	2	603C	2	SAB	1	SUAS	1		
5815-00-140-8604	601C	2	602C	2	603C	2	SAB	1	SUAS	1		
5815-00-489-6642	601C	2	602C	2	603C	2	SAB	1	SUAS	1		
5895-00-450-8365	601C	2	602C	2	603C	2	SAB	1	SUAS	1		
5895-00-450-8366	601C	2	602C	2	603C	2	SAB	1	SUAS	1		
5805-00-466-3086	601C	2	602C	2	603C	2	SAB	1	SUAS	1		
5805-00-488-4610	601C	2	602C	2	603C	2	SAB	1	SUAS	1		
5814-01-114-6703	601C	2	602C	2	603C	2	SAB	1	SUAS	1		
5805-00-999-5032	612F	2	621F	2	631F	2	632F	2	611F	2	622F	2
5805-00-999-5032	SAB	1	SUAS	1								
5820-00-167-7673	612F	2	621F	2	631F	2	632F	2	611F	2	622F	2
5820-00-167-7673	SAB	1	SUAS	1								
5820-00-167-7675	612F	2	621F	2	631F	2	632F	2	611F	2	622F	2
5820-00-167-7675	SAB	1	SUAS	1								
5820-00-226-5367	612F	2	621F	2	631F	2	632F	2	611F	2	622F	2
5820-00-226-5367	SAB	1	SUAS	1								
5820-00-226-5368	612F	2	621F	2	631F	2	632F	2	611F	2	622F	2
5820-00-226-5368	SAB	1	SUAS	1								
5820-00-226-5436	612F	2	621F	2	631F	2	632F	2	611F	2	622F	2
5820-00-226-5436	SAB	1	SUAS	1								
5820-00-924-8465	612F	2	621F	2	631F	2	632F	2	611F	2	622F	2
5820-00-924-8465	SAB	1	SUAS	1								
5821-00-138-7991	612F	2	621F	2	631F	2	632F	2	611F	2	622F	2
5821-00-138-7991	SAB	1	SUAS	1								
5821-00-570-4232	612F	2	621F	2	631F	2	632F	2	611F	2	622F	2
5821-00-570-4232	SAB	1	SUAS	1								
5821-00-576-4866	612F	2	621F	2	631F	2	632F	2	611F	2	622F	2
5821-00-576-4866	SAB	1	SUAS	1								
5945-00-991-8258	601C	10	602C	10	603C	10	SAB	2	SUAS	1		
3030-00-482-8284	601C	5	602C	5	603C	5	SAB	1	SUAS	1		
5820-00-005-1867	601C	2	602C	2	603C	2	SAB	1	SUAS	1		
5820-00-005-8628	601C	2	602C	2	603C	2	SAB	1	SUAS	1		
5820-00-006-1122	601C	2	602C	2	603C	2	SAB	1	SUAS	1		
5820-00-006-1123	601C	2	602C	2	603C	2	SAB	1	SUAS	1		
5820-00-260-0412	601C	2	602C	2	603C	2	SAB	1	SUAS	1		
5820-00-409-2470	601C	2	602C	2	603C	2	SAB	1	SUAS	1		
5820-00-492-9770	601C	2	602C	2	603C	2	SAB	1	SUAS	1		
5820-00-492-9774	601C	2	602C	2	603C	2	SAB	1	SUAS	1		

Changed Methodology Input

This section includes the scenario portions of the files used in the changed methodology runs. Also presented are the LRU inputs which reflect changes made to model the forward stock locations.

Northern Scenario One.

```
THESIS:  AFIT/GLM/LSM/84S-43  CAPT R D MABE AND CAPT R E ORMSTON
11.500              VERSION 4.3  MT1MT2MT3MT4MT5
   5  10  20  30  45  60  75  90
OPT
     11  00.80
      8  70
     13
     14
     15
DEPT
SAB                                    180.01          180. 180. 180. 0     10.00
CIRF
HOAS                                        1                         0     3.00
BASE
606CHOAS2.0002.0001.00 01.00 3.00                      1.0001.0001.00000.0  1.00     1
609CHOAS1.0001.0001.00 01.00 3.00                      1.0001.0001.00000.0  1.00     1
626FHOAS2.0002.0001.00 01.00 3.00                      1.0001.0001.00000.0  1.00     1
636FHOAS2.0002.0001.00 01.00 3.00                      1.0001.0001.00000.0  1.00     1
619FHOAS1.0001.0001.00 01.00 3.00                      1.0001.0001.00000.0  1.00     1
629FHOAS1.0001.0001.00 01.00 3.00                      1.0001.0001.00000.0  1.00     1
TRNS
HOAS  SAB   .250   .250  0 1.0   180.  1.0
606C  SAB  2.000 2.000  0 3.0   19.0  3.0
609C  SAB  2.000 2.000  0 3.0   180.  1.0
626F  SAB  2.000 2.000  0 3.0   23.0  1.0
636F  SAB  2.000 2.000  0 3.0   23.0  1.0
619F  SAB  2.000 2.000  0 3.0   20.0  1.0
629F  SAB  2.000 2.000  0 3.0   26.0  1.0
ACFT
606C  0.    1  1.  99  0.
609C  0.    1  1.  99  0.
626F  0.    1  1.  99  0.
636F  0.    1  1.  99  0.
619F  0.    1  1.  99  0.
629F  0.    1  1.  99  0.
SRTS
606C  0.    124.0  190.0   2224.0 .990.0
609C  0.    124.0  1924.0  990.0
626F  0.    124.0  1924.0  230.0   2424.0  990.0
636F  0.    124.0  1924.0  230.0   2424.0  990.0
619F  0.    124.0  1924.0  200.0   2124.0  990.0
629F  0.    124.0  1924.0  260.0   2724.0  990.0
FLHR
606C 0.     1 1.0  99 0.
609C 0.     1 1.0  99 0.
626F 0.     1 1.0  99 0.
636F 0.     1 1.0  99 0.
619F 0.     1 1.0  99 0.
629F 0.     1 1.0  99 0.
ATTR
606C0.       10.      990.
609C0.       10.      990.
626F0.       10.      990.
636F0.       10.      990.
619F0.       10.      990.
629F0.       10.      990.
TURN
606C24.01 990.
609C24.01 990.
626F24.01 990.
636F24.01 990.
619F24.01 990.
629F24.01 990.
```

__Northern__ __Scenario__ __Two__. The inputs used in scenario two were identical to the inputs used in scenario one, except for the second line in the scenario two file. The second line was changed to read:

```
01.500                  VERSION 4.3 MT1MT2MT3MT4MT5
```

to reflect a change in the cutoff switch.

__Southern__ __Scenario__ __One__.

```
THESIS: AFIT/GLM/LSM/84S43  CAPT R D MABE AND CAPT R E ORMSTON
11.500             VERSION 4.3  MT1MT2MT3MT4MT5
    5  10  20  30  45  60  75  90
OPT
      11  0.80
       8  70
      13
      14
      15
DEPT
SAB                                180.01          180. 180. 180. 0     10.00
BASE
601C                                               1.0001.0001.00000.0  1.00     1
602C                                               1.0001.0001.00000.0  1.00     1
603C                                               1.0001.0001.00000.0  1.00     1
612F                                               1.0001.0001.00000.0  1.00     1
621F                                               1.0001.0001.00000.0  1.00     1
631F                                               1.0001.0001.00000.0  1.00     1
632F                                               1.0001.0001.00000.0  1.00     1
611F                                               1.0001.0001.00000.0  1.00     1
622F                                               1.0001.0001.00000.0  1.00     1
TRNS
601C SAB  2.000 2.000 0 3.0   180.  1.0
602C SAB  2.000 2.000 0 3.0   21.0  2.0
603C SAB  1.000 1.000 0 3.0   180.  1.0
612F SAB  2.000 2.000 0 3.0   20.0  1.0
621F SAB  2.000 2.000 0 3.0   19.0  1.0
631F SAB  2.000 2.000 0 3.0   23.0  1.0
632F SAB  2.000 2.000 0 3.0   180.  1.0
611F SAB  1.000 1.000 0 3.0   21.0  1.0
622F SAB  1.000 1.000 0 3.0   26.0  1.0
ACFT
601C  0.    1  1.9999  0.
602C  0.    1  1.9999  0.
603C  0.    1  1.9999  0.
612F  0.    1  1.9999  0.
621F  0.    1  1.9999  0.
631F  0.    1  1.9999  0.
632F  0.    1  1.9999  0.
611F  0.    1  1.9999  0.
622F  0.    1  1.9999  0.
SRTS
601C  0.    10.0     324.0  120.0   1624.0
602C  0.    10.0     224.0  210.0   2324.0
603C  0.    124.0
612F  0.    10.0     324.0  160.0   1724.0  200.0   2124.0
621F  0.    124.0    80.0     924.0 190.0   2024.0
631F  0.    10.0     324.0  120.0   1324.0  230.0   2424.0
632F  0.    10.0     324.0   60.0    724.0  170.0   1824.0
611F  0.    124.0   110.0   1224.0  210.0   2224.0
622F  0.    124.0   140.0   1524.0  260.0   2724.0
FLHR
601C 0.     1 1.09999 0.
602C 0.     1 1.09999 0.
603C 0.     1 1.09999 0.
612F 0.     1 1.09999 0.
621F 0.     1 1.09999 0.
631F 0.     1 1.09999 0.
632F 0.     1 1.09999 0.
611F 0.     1 1.09999 0.
622F 0.     1 1.09999 0.
```

Southern Scenario Two. The inputs used in scenario two were identical to the inputs used in scenario one, except for the addition of a CIRF card to model the forward stock location:

```
CIRF
SUAS                          1                         0     1.00
```

LRU Input Changes. The changes made to the LRU cards were identical for both the Northern and Southern region, and are presented below:

```
LRU
5895-00-400-8106 SAB   1 1 01 01 0 .00016        1.0  0.0  0.00 1.0  0.0  0.00
5895-00-400-8106 0.0   1.0         180. 99.0     180. 180. 623.15   TPS43EC 1
5840-00-162-1231 SAB   1 1 01 01 0 .00113        1800 .470 0.00 1800 .470 0.00
5840-00-162-1231 0.0   1.0         180. 99.0     180. 180. 53817.50 TPS43EC 1
5960-00-078-0684 SAB   1 1 01 01 0 .00099        3.00 .920 0.00 3.00 .920 0.00
5960-00-078-0684 0.0   1.0         180. 99.0     180. 180. 48523.30 TPS43EC 1
5840-00-396-1208 SAB   1 1 01 01 0 .00154        8.00 .160 0.00 8.00 .160 0.00
5840-00-396-1208 0.0   1.0         180. 99.0     180. 180. 300.76   TPS43EC 1
5840-00-572-1617 SAB   1 1 01 01 0 .00090        1200 .190 0.00 1200 .190 0.00
5840-00-572-1617 0.0   1.0         180. 99.0     180. 180. 21408.55 TPS43EC 1
5840-01-027-0315 SAB   1 1 01 01 0 .00066        2800 .600 0.00 2800 .600 0.00
5840-01-027-0315 0.0   1.0         180. 99.0     180. 180. 14690.98 TPS43EC 1
5840-01-034-4607 SAB   1 1 01 01 0 .00021        9.00 .800 0.00 9.00 .800 0.00
5840-01-034-4607 0.0   1.0         180. 99.0     180. 180. 32450.15 TPS43EC 1
5840-01-035-1166 SAB   1 1 01 01 0 .00209        1.00 .980 0.00 1.00 .980 0.00
5840-01-035-1166 0.0   1.0         180. 99.0     180. 180. 3234.20  TPS43EC 1
5895-00-400-8104 SAB   1 1 01 01 0 .00027        1700 0.00 0.00 1700 0.00 0.00
5895-00-400-8104 0.0   1.0         180. 99.0     180. 180. 516.64   TPS43EC 1
5895-00-400-8108 SAB   1 1 01 01 0 .00036        1000 .460 0.00 1000 .460 0.00
5895-00-400-8108 0.0   1.0         180. 99.0     180. 180. 1089.74  TPS43EC 1
5840-01-037-5526 SAB   1 1 01 01 0 .00023        1900 .570 0.00 1900 .570 0.00
5840-01-037-5526 0.0   1.0         180. 99.0     180. 180. 26079.60 TPS43EC 1
5840-01-055-9558 SAB   1 1 01 01 0 .00083        6.00 0.00 0.00 6.00 0.00 0.00
5840-01-055-9558 0.0   1.0         180. 99.0     180. 180. 4381.49  TPS43EC 1
6130-00-443-6963 SAB   1 1 06 03 0 .00025        3.00 .620 0.00 3.00 .620 0.00
6130-00-443-6963 0.0   1.0         180. 99.0     180. 180. 1158.75  24U-8C  1

6115-00-456-3904 SAB   1 1 06 03 0 .00046        2.00 .950 0.00 2.00 .950 0.00
6115-00-456-3904 0.0   1.0         180. 99.0     180. 180. 14028.60 24U-8C  1
6110-00-442-7513 SAB   1 1 06 03 0 .00055        8.00 .620 0.00 8.00 .620 0.00
6110-00-442-7513 0.0   1.0         180. 99.0     180. 180. 1446.00  24U-8C  1
6110-00-442-7488 SAB   1 1 06 03 0 .00066        1200 .310 .308 1200 .310 .308
6110-00-442-7488 0.0   1.0         180. 99.0     180. 180. 752.62   24U-8C  1
6110-00-442-7478 SAB   1 1 06 03 0 .00034        9.00 .160 .164 9.00 .160 .164
6110-00-442-7478 0.0   1.0         180. 99.0     180. 180. 165.02   24U-8C  1
2910-00-109-2539 SAB   1 1 06 03 0 .00026        1000 .450 .373 1000 .450 .373
2910-00-109-2539 0.0   1.0         180. 99.0     180. 180. 357.50   24U-8C  1
6110-00-442-7469 SAB   1 1 06 03 0 .00045        7.00 .120 .062 7.00 .120 .062
6110-00-442-7469 0.0   1.0         180. 99.0     180. 180. 215.72   24U-8C  1
6110-00-442-7477 SAB   1 1 06 03 0 .00054        5.00 .270 .265 5.00 .270 .265
6110-00-442-7477 0.0   1.0         180. 99.0     180. 180. 196.28   24U-8C  1
5820-00-917-6578 SAB   1 1 08 02 0 .00031        5.00 .670 0.00 5.00 .670 0.00
5820-00-917-6578 0.0   1.0         180. 99.0     180. 180. 2054.85  TRC-97  1
5820-00-917-8303 SAB   1 1 08 02 0 .00041        1000 .160 0.00 1000 .160 0.00
5820-00-917-8303 0.0   1.0         180. 99.0     180. 180. 3091.00  TRC-97  1
5820-00-921-6562 SAB   1 1 08 02 0 .00010        3.00 .600 0.00 3.00 .600 0.00
5820-00-921-6562 0.0   1.0         180. 99.0     180. 180. 1462.00  TRC-97  1
5820-00-921-6565 SAB   1 1 08 02 0 .00103        1700 .230 0.00 1700 .230 0.00
5820-00-921-6565 0.0   1.0         180. 99.0     180. 180. 3582.34  TRC-97  1
5820-00-921-6566 SAB   1 1 08 02 0 .00008        6.00 0.00 0.00 6.00 0.00 0.00
5820-00-921-6566 0.0   1.0         180. 99.0     180. 180. 600.60   TRC-97  1
5820-00-921-6569 SAB   1 1 08 02 0 .00030        1400 .620 0.00 1400 .620 0.00
5820-00-921-6569 0.0   1.0         180. 99.0     180. 180. 291.53   TRC-97  1
5820-00-921-6570 SAB   1 1 08 02 0 .00001        5.00 0.00 0.00 5.00 0.00 0.00
5820-00-921-6570 0.0   1.0         180. 99.0     180. 180. 251.47   TRC-97  1
5820-00-921-6571 SAB   1 1 08 02 0 .00008        1100 0.00 0.00 1100 0.00 0.00
5820-00-921-6571 0.0   1.0         180. 99.0     180. 180. 334.75   TRC-97  1
5820-00-921-6574 SAB   1 1 08 02 0 .00032        1400 .320 0.00 1400 .320 0.00
5820-00-921-6574 0.0   1.0         180. 99.0     180. 180. 888.90   TRC-97  1
5820-00-921-6696 SAB   1 1 08 02 0 .00020        8.00 .170 0.00 8.00 .170 0.00
5820-00-921-6696 0.0   1.0         180. 99.0     180. 180. 754.00   TRC-97  1
5820-00-123-3954 SAB   1 1 06 02 0 .00033        1200 .600 0.00 1200 .600 0.00
5820-00-123-3954 0.0   1.0         180. 99.0     180. 180. 1903.00  TRC-87C 1
```

```
5820-00-252-2759 SAB  1 1 06 02 0 .00043     1200 .850 0.00 1200 .850 0.00
5820-00-252-2759 0.0  1.0        180. 99.0   180. 180. 1555.30  TRC-87C 1
5820-00-485-8881 SAB  1 1 09 03 0 .00020     9.00 .100 0.00 9.00 .100 0.00
5820-00-485-8881 0.0  1.0        180. 99.0   180. 180. 68.31    TRC-87C 1
5820-00-401-8061 SAB  1 1 09 03 0 .00043     1300 .470 0.00 1300 .470 0.00
5820-00-401-8061 0.0  1.0        180. 99.0   180. 180. 417.20   TRC-87  1
5820-00-416-8546 SAB  1 1 09 03 0 .00016     0.00 1.00 0.00 0.00 1.00 0.00
5820-00-416-8546 0.0  1.0        180. 99.0   180. 180. 1569.30  TRC-87  1
5820-00-416-8552 SAB  1 1 09 03 0 .00008     9.00 .670 0.00 9.00 .670 0.00
5820-00-416-8552 0.0  1.0        180. 99.0   180. 180. 216.30   TRC-87  1
5820-00-427-9429 SAB  1 1 09 03 0 .00008     0.00 1.00 0.00 0.00 1.00 0.00
5820-00-427-9429 0.0  1.0        180. 99.0   180. 180. 1256.60  TRC-87  1
5820-00-437-9952 SAB  1 1 06 02 0 .00004     1.00 .500 0.00 1.00 .500 0.00
5820-00-437-9952 0.0  1.0        180. 99.0   180. 180. 303.90   TRC-87  1
5820-00-491-4046 SAB  1 1 09 03 0 .00027     2.00 .310 0.00 2.00 .310 0.00
5820-00-491-4046 0.0  1.0        180. 99.0   180. 180. 275.01   TRC-87  1
5820-00-494-8815 SAB  1 1 09 03 0 .00052     8.00 .240 0.00 8.00 .310 0.00
5820-00-494-8815 0.0  1.0        180. 99.0   180. 180. 180.25   TRC-87  1
5815-00-050-0230 SAB  1 1 01 01 0 .00095     4.00 0.00 0.00 4.00 0.00 0.00
5815-00-050-0230 0.0  1.0        180. 99.0   180. 180. 402.78   TGC-28C 1
5815-00-028-4324 SAB  1 1 01 01 0 .00016     1500 0.00 0.00 1500 0.00 0.00
5815-00-028-4324 0.0  1.0        180. 99.0   180. 180. 1396.80  TGC-28C 1
5815-00-489-6641 SAB  1 1 01 01 0 .00010     4.00 .330 0.00 4.00 .330 0.00
5815-00-489-6641 0.0  1.0        180. 99.0   180. 180. 1531.00  TGC-28C 1
5815-00-140-8604 SAB  1 1 01 01 0 .00008     8.00 0.00 0.00 8.00 0.00 0.00
5815-00-140-8604 0.0  1.0        180. 99.0   180. 180. 496.50   TGC-28C 1
5815-00-489-6642 SAB  1 1 01 01 0 .00008     1.00 .500 0.00 1.00 .500 0.00
5815-00-489-6642 0.0  1.0        180. 99.0   180. 180. 1531.00  TGC-28  1
5895-00-450-8365 SAB  1 1 01 01 0 .00008     5.00 0.00 0.00 5.00 0.00 0.00
5895-00-450-8365 0.0  1.0        180. 99.0   180. 180. 350.00   TGC-28  1
5895-00-450-8366 SAB  1 1 01 01 0 .00023     4.00 0.00 0.00 4.00 0.00 0.00
5895-00-450-8366 0.0  1.0        180. 99.0   180. 180. 1462.00  TGC-28  1
5805-00-466-3086 SAB  1 1 01 01 0 .00004     1.00 0.00 0.00 1.00 0.00 0.00
5805-00-466-3086 0.0  1.0        180. 99.0   180. 180. 836.70   TGC-28  1
5805-00-488-4610 SAB  1 1 01 01 0 .00016     1500 0.00 0.00 1500 0.00 0.00
5805-00-488-4610 0.0  1.0        180. 99.0   180. 180. 1383.00  TGC-28  1
5814-01-114-6703 SAB  1 1 01 01 0 .00004     1400 0.00 0.00 1400 0.00 0.00
5814-01-114-6703 0.0  1.0        180. 99.0   180. 180. 1937.43  TGC-28  1
5805-00-999-5032 SAB  1 1 01 01 0 .00021     9.00 .200 0.00 9.00 .200 0.00
5805-00-999-5032 0.0  1.0        180. 99.0   180. 180. 80.40    TSC-53C 1
5820-00-167-7673 SAB  1 1 01 01 0 .00012     0.00 1.00 0.00 0.00 1.00 0.00
5820-00-167-7673 0.0  1.0        180. 99.0   180. 180. 4330.00  TSC-53  1
5820-00-167-7675 SAB  1 1 01 01 0 .00016     8.00 .500 0.00 8.00 .500 0.00
5820-00-167-7675 0.0  1.0        180. 99.0   180. 180. 1930.00  TSC-53  1
5820-00-226-5367 SAB  1 1 01 01 0 .00008     0.00 0.00 1.00 0.00 0.00 1.00
5820-00-226-5367 0.0  1.0        180. 99.0   180. 180. 174.00   TSC-53  1
5820-00-226-5368 SAB  1 1 01 01 0 .00008     0.00 1.00 0.00 0.00 1.00 0.00
5820-00-226-5368 0.0  1.0        180. 99.0   180. 180. 304.00   TSC-53  1
5820-00-226-5436 SAB  1 1 01 01 0 .00004     0.00 1.00 0.00 0.00 1.00 0.00
5820-00-226-5436 0.0  1.0        180. 99.0   180. 180. 525.00   TSC-53  1
5820-00-924-8465 SAB  1 1 01 01 0 .00025     1400 .670 0.00 1400 .670 0.00
5820-00-924-8465 0.0  1.0        180. 99.0   180. 180. 1278.00  TSC-53  1
5821-00-138-7991 SAB  1 1 01 01 0 .00016     1.00 0.00 0.00 1.00 0.00 0.00
5821-00-138-7991 0.0  1.0        180. 99.0   180. 180. 4729.00  TSC-53  1
5821-00-570-4232 SAB  1 1 01 01 0 .00033     3.00 .800 0.00 3.00 .800 0.00
5821-00-570-4232 0.0  1.0        180. 99.0   180. 180. 956.87   TSC-53  1
5821-00-576-4866 SAB  1 1 01 01 0 .00046     1300 .790 0.00 1300 .790 0.00
5821-00-576-4866 0.0  1.0        180. 99.0   180. 180. 1866.36  TSC-53  1
5945-00-991-8258 SAB  1 1 15 03 0 .00111     0.00 0.00 1.00 0.00 0.00 1.00
5945-00-991-8258 0.0  1.0        180. 99.0   180. 180. 70.21    TSC-60C 1
3030-00-482-8284 SAB  1 1 05 01 0 .00014     0.00 0.00 1.00 0.00 0.00 1.00
3030-00-482-8284 0.0  1.0        180. 99.0   180. 180. 3.24     TSC-60C 1
5820-00-005-1867 SAB  1 1 05 01 0 .00008     9.00 0.00 0.00 9.00 0.00 0.00
5820-00-005-1867 0.0  1.0        180. 99.0   180. 180. 1564.00  TSC-60  1
5820-00-005-8628 SAB  1 1 05 01 0 .00033     1.00 .700 0.00 1.00 .700 0.00
5820-00-005-8628 0.0  1.0        180. 99.0   180. 180. 20958.00 TSC-60  1
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Appendix B: Glossary

Term	Meaning
AAFCE	Allied Air Forces Central Europe
ADGE	Air Defense Ground Environmet
AFCC	Air Force Communications Command
AFLC	Air Force Logistics Command
AFLMC	Air Force Logistics Management Center
ATAF	Allied Tactical Air Force
CE	Communications-Electronic
CIRF	Centralized Intermediate Repair Facility
CRP	Control Reporting Post
FACP	Forward Air Control Post
FMC	Fully Mission Capable
FSL	Forward Stock Location
HF	High Frequency
HOAS	Hessisch-Oldendorf Air Station
LRC	Logistics Readiness Center
LRU	Line Replaceable Unit
MDS	Mission Design Series
NATO	North Atlantic Treaty Organization
NMC	Not Mission Capable
NMCS	Not Mission Capable Supply
NRTS	Not Repareable This Station
OST	Order and Ship Time
PMC	Partially Mission Capable

PPS	Prepositioned Stock
QPA	Quantity per Aircraft
RCT	Repair Cycle Time
RR	Remove and Replace
RRR	Remove, Repair, and Replace
SAB	Sembach Air Base
SHF	Super High Frequency
SOC	Sector Operations Center
SRU	Shop Replaceable Unit
TACS	Tactical Air Control System
TCW	Tactical Control Wing
UHF	Ultra High Frequency
USAFE	United States Air Forces Europe
WRM	War Reserve Materiel
WRSK	War Reserve Spares Kit

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Captain Richard D. Mabe was born 1 June 1953 in Nampa, Idaho. He graduated from high school in Nampa in 1971, and entered the US Army in November 1971. He attended interrogator and foreign language training before being assigned to the 529 Military Intelligence Company at Fort Hood, Texas. He was honorably discharged from the Army in November 1974 and began attending college at Boise State University, Boise, Idaho. Following graduation from college he entered the Air Force Officer Training School, Lackland, AFB Texas, and was commissioned on 23 December 1977. He served as the Materiel Support Officer in base supply at McGuire AFB, New Jersey from January 1978 to May 1979. He then began a career broadening assignment as a Weapons Controller assigned to the 602 Tactical Control Squadron, Neu Ulm, Germany. In July 1981, he was assigned to the 601 Tactical Control Wing staff at Sembach Air Base, Germany where he served as the Chief of the Ground Environment Stan/Eval Branch. He entered the School of Systems and Logistics, Air Force Institute of Technology in May 1983.

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This investigation determined that there is an improved way to structure the resupply system used to support the USAFE TACS. After analyzing the resupply system, and examining six alternative resupply systems qualitatively, the "best" method of resupply was postulated to be one using several forward supply points (prepositioned stock) with dedicated transportation assets to support these points.

This "best" method was then modeled using the Dyna-METRIC model developed by the Rand Corporation. This model was originally developed for application to aircraft systems. This thesis represents the first time the model was adapted to accomodate mobile communications-electronics equipment. The model compared the proposed "best" method of resupply against the resupply system currently in use in USAFE. The model quantitatively substantiated the proposed "best" system could improve resupply support for the USAFE TACS.

Two significant findings were derived from this study. First, the Dyna-METRIC model is flexible enough to accomodate systems other than fighter aircraft. Secondly, intra-theater prepositioning is a viable concept which can enhance supply support for the USAFE TACS.